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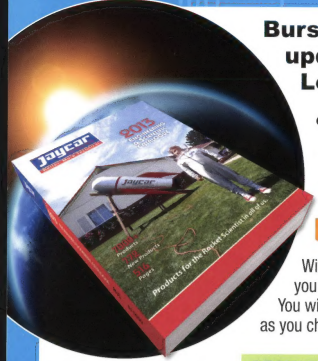

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There are a few exceptional projects which we think deserve special mention and an extra reward. All these details will be posted on our website before the end of March 2013.

Again our thanks for your participation.
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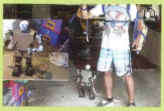
Toni Martin
CEO Jaycar Electronics



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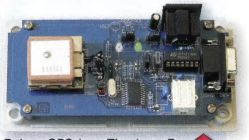

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Publisher's Letter

Our new website is up and running

After what seems like a very long gestation period, our new website is up and running. In fact, at the time of writing it has been running for more than a month but it is only very recently that we have had it running with full credit card facilities. It is with considerable relief that I am writing this Publisher's Letter but I am also aware that any website tends to be a work in progress and that there is always something that needs fixing or improving.

If you visit the website you will find that we have all the issues going back to the beginning of 2004, a total of 135 issues (and growing) and almost 13000 pages in all, including most of the advertisements. This has been an enormous task, especially considering that we have incorporated most of the Notes & Errata that has been published for all of these issues.

Nicholas Vinen has played the major part in constructing and writing the software for our new website, ably backed up by the rest of our staff in revising layouts, proof-reading, correcting circuits and a host of other time-consuming tasks. My heart-felt thanks to everyone involved.

While the overall presentation of SILICON CHIP is a vast improvement over the previous website, I am also delighted that we can now provide on-line access to any subscriber who presently has a print magazine subscription, for a small extra fee. Many subscribers have asked for this service in the past and now you can have it. So if you have a one-year subscription for 2013, you can also have on-line access to those issues. Or to any or all of the years going back to 2004. So that's good.

But some readers have been very critical because they have Apple iPads and other Apple products which do not support Adobe Flash. This is unfortunate but this was a decision by Apple, not us. We hope to provide a workable solution but it must be said that an on-line magazine like SILICON CHIP which displays in double-page spreads with page-turning is never going to work particularly well on tablets.

This is mainly because SILICON CHIP often features large circuit diagrams and photos which spread over two pages. Moreover, the resolution on most tablets is simply not good enough to enable you to closely read and pore over the circuit diagrams and photos. We know that our readers like to go though the issues with a fine-tooth comb and while that is easy with a printed magazine, it doesn't work too well with a tablet or a screen with poor resolution.

Some readers will also be disappointed because we have not made the magazine available in PDF format. The problem with that is that it is too easy to copy and distribute. We already have great problems with piracy and with copying in general. Most readers are honest and some even go to the trouble of alerting us to websites where SILICON CHIP articles are being used without acknowledgement or authorisation. Thanks very much to those devoted readers. They recognise that if SILICON CHIP'S intellectual property is stolen then long-term viability suffers.

In fact, magazines and newspapers worldwide are suffering from the inroads of the internet and if magazine publishers cannot make money from their content, there will soon be no magazines, at least not in a format which is likely to be viable and supporting a technical staff. And while we do allow previews of the magazine articles, we simply must charge for access to the full articles. Any publication which does not charge for its content will soon disappear, as many already have.

I hope that you use and enjoy our on-line magazine. We have endeavoured to make it as close to the print magazine as possible but it will have more features as we develop it. Have a good look at the article starting on page 20 of this issue and also at the FAQs (frequently asked questions) on the website.

Leo Simpson

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MAILBAG

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Nuclear option is unsafe

While the Rubicon article in the February 2013 issue was interesting, I was concerned to read in the last few lines "... a nuclear option with few environmental impacts ..." I don't know Dr Maddison's area of expertise but I can safely assume it's not in nuclear power. To state that nuclear power stations have no environmental impact is not only wrong, it's dangerous.

Most people are aware of the disasters in Chernobyl and Fukushima, and perhaps Three Mile Island (to name only three of the best known), which resulted in thousands of deaths (and more to come), as well as massive damage to the environment, most of which can never be reversed, but most people are probably not aware of the other environmental damage caused by mining uranium.

For example, tailings at mine sites can contain significant amounts of radioactivity, while the cooling water needed at the power stations kills millions of fish and damages the marine environment when it is returned to rivers and seas at a greatly increased temperature. In our own case, Roxby Downs has destroyed ancient springs, Ranger has poisoned Kakadu wetlands and Beverly has polluted groundwater. This is without considering the huge increase in cancer rates among all uranium mine workers and those people living within a large radius of an existing nuclear power station.

There is no satisfactory method for storing the radioactive waste from power stations, which has to be done for thousands of years. On top of all this, nuclear energy is not even economical.

For anyone still not convinced, I refer them to Gar Smith's book called "Nuclear Roulette", which is comprehensively referenced and details the stupidity of building nuclear power stations. Anyone not convinced after reading this book would have to be in denial or lacking a brain.

Alex Danilov,
Naremburn, NSW.

Comment: while damage to the environment is considerable in the case of Fukushima, we don't know of any documented deaths due to the leakage of radioactivity. Nor, as far as we know, have there been any documented deaths due to the Three Mile Island event.

GPS timebase accuracy may be over-stated

I have read SILICON CHIP with interest since I left Australia more than 10 years ago. I congratulate you for the success and interesting articles published over the years.

For this reason I suggest that your writers and editors be more careful and realistic in making claims such as 1 part in 10^{11} accuracy in the GPS timebase article by Jim Rowe (February 2013). This accuracy cannot be achieved with the simple circuit shown. The main problem is frequency jitter and up to 100ns or even 1µs jitters are not uncommon in most modules.

One approach is by long-time averaging and a circuit that can average the 1pps pulses over 20-100s intervals may be able to achieve 1 part per billion (1 ppb), comparable to a rubidium standard. Averaging techniques suffer from diminishing return as over an hour averaging will only get you at most 0.1 ppb accuracy, so 0.01 ppb as claimed by Jim is a rather tall order.

If Aussie readers need more guidance in this regard, Andy Talbot has written an excellent article on what can be achieved with the various standards in "Design Notes" RadCom RSGB Jan 2013 UK. See:
http://www.rsgb.org/news-radcom/radcom/?month=January&year=2013

Tuck Choy,
London, UK.

Comment: you may well be right in suggesting that frequency jitter in the GPS module used in the timebase would mean that the claimed order of accuracy is unlikely to be achieved.

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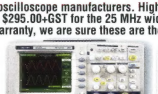
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However, tests done by Jim Rowe over the last couple of months using the GPS Timebase and the 12-digit Counter (set to average the GPS 1pps timebase pulses over 1000 seconds) to measure the GPS-locked 10MHz output from our GPS-based Frequency Reference (SILICON CHIP, March-May 2007) have given readings with a long term accuracy of 10MHz ±0.003Hz – ie, ±3 parts in 10^{10}.

This error range would include jitter in both the GPS Timebase and the GPS-based Frequency Reference, which uses a different GPS receiver module with an external active antenna.

So while we accept your criticism that the claimed 1 part in 10^{11} may be a little optimistic, we think it's still quite realistic to modify the claimed accuracy to ±3 parts in 10^{10}. Since we don't have an atomic standard frequency reference, it is not possible for us to determine the absolute accuracy which could be achieved.

48V house power would need battery storage

I wondered when someone would get around to asking about running a house from solar panels, without "guidance" from the grid (Mailbag, February 2013, page 10). Of course, it would need battery storage. The comment that a domestic supply should be 48V has my support.

You might make enquiries about what voltage was used during the steam era of trains. In Queensland, the ones I saw were 48V and this meant that thin wires could be used compared with lower voltages; not that much current was needed for the dim railway filament lamps.

Some authorities believe that 50V is the safe limit of any system which may be contacted by humans; it is believed that 50V will not seriously injure a human.

Certainly, if such domestic installations become common, there should be some way of preventing plugging-in of low voltage equipment into the 230/240V system; circa 1955, we had no problem when a demonstrator in an electrical store plugged a 32V floor polisher into the 240VAC and switched it on, except to calm the demonstrator!

What would be most requested by householders? Some would expect some form of light and modern high-brightness LEDs would certainly fit in with this idea.

Wind farms and "free energy"

I recently read your Publisher's Letter on wind farms in the March 2013 issue and felt it really didn't cover the topic as I see it. Wind farms are free energy and, with carbon dioxide increasing in our atmosphere at an exponential rate, any solar source leading to a reduction in CO_2 is worthwhile.

Coal power based companies are constantly firing up gas powered generators to meet the peak and fluctuating demands of consumers. However, wind farms are just a small part of the equation. Wind farms should be complemented with solar radiation farms, wave energy farms and hydro schemes. The hydro scheme is the battery in the system that can pump water up into its lake above when excess solar power is being generated and when solar power is missing it can be used to fill the gaps.

Within Australia, there are plenty of areas where there are mountains in close proximity to the coast. If only our government could see this big picture and spend our money on systems that really benefit the community instead of spending so much money on vote buying policies (eg, the NBN). They require toughness to build these facilities. I see them legislating to build roads but I do not see them legislating construct these solar systems. What a shame.

Hamish Rouse,
Mt Martha, Vic.

Comment: regarding wind farms as free energy is a mistake. Regardless of their claim to zero pollution and no fossil fuel use, wind farms are not free. They are a huge cost to taxpayers and electricity consumers. All wind farms need gas-fired generators as back-up and they are owned by companies such as AGL and Origin Energy, not coal miners.

Hydroelectric schemes are certainly an effective form of pumped storage but they have been vehemently opposed by environmentalists.

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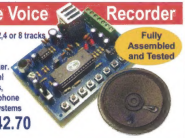

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Mailbag: continued

Ignition for twin-cylinder motorbikes

With respect to the letters from O. O. and G. G. in the March 2013 issue (page 90), regarding full electronic ignition systems for Moto Guzzi motorcycles, I assume that you agree that almost any twin-cylinder motorcycle can be converted to twin-trigger full electronic ignition with a programmable timing map.

With respect to Moto Guzzis, almost all of them (excluding relatively recent fuel-injected models which already have full electronic ignition systems) can be converted to a twin-trigger full electronic ignition system. This is done by modifying the distributor shaft and housing to take a rotating vane and two stationary Hall Effect, reluctor or optical sensors to provide accurate separate triggers for each cylinder.

The common firing angles for twins (excluding Harley Davidson, Moto Morini etc) are 360°, 180° and 90°. With almost all motorcycles, the camshafts rotate at half crankshaft speed (ie, two crankshaft revolutions for each camshaft revolution), so it should be possible to fire the plugs only at the top of the compression stroke. Unfortunately, some ignition systems in twin-cylinder motorcycle engines simply fire at the top of both the compression and exhaust strokes.

This is definitely not the best way to do it but may be almost unavoidable with a few engine designs. Those who wish to overcome this problem could install a steel pin in the cam sprocket (or in the cam gear, in gear-driven valve timing systems) with an appropriately placed reluctor pickup screwed into the engine case, to differentiate the compression stroke from the exhaust stroke.

In any case, we are not talking rocket science when considering converting older Moto Guzzis, BMWs, Nortons, Triumphs etc, to twin-trigger full electronic ignition systems. This sort of upgrade promises significantly better fuel economy and power.

With the cost of fuel these days, a Silicon Chip project for a full electronic ignition system for older (particularly carburettor-fueled) twin-cylinder motorcycles would be greatly appreciated by innumerable motorcyclists and would be a world first for an electronics hobby magazine. I have no doubt that news of such a project would spread like wildfire through the twin-cylinder motorcycle internet forums throughout the world.

Otto Hoolhorst,
Brisbane, Qld.

The major household need would be refrigeration and that has certain demands. The starting current of a normal domestic refrigerator is quite high and some understanding of this is needed; also the technique of supplying power to only one refrigerator until it has started, then turning on another if there are several in the house. Mostly, two refrigerators can be run at the same time from most standby supplies, provided the standby supply is capable. We had

some experience of running a household from a petrol generator a few years ago and other needs can be supplied without grid-based electricity.

There are some emergency needs which depend on grid-based electricity but usually these are known in advance and provision can be made for them. Perhaps one of the best measures is to decide if storm winds can blow down trees and interrupt the normal mains supply (from the grid).

Unfortunately, while it may be not too difficult to run a domestic refrigerator from a solar panel (and inverter), the time when it is needed may be when there is insufficient sunlight.

One aspect which seems to have not been raised concerns house insurance. The very nature of 48V supplies implies that there will be a lot of DIY installations and these will be quite susceptible to fire hazard. Again circa 1950, I was told that many 32V installations were DIY and that to have house insurance, the usual practice was to seek a licensed electrician to certify the installation. I saw enough during my seven years with an electrical store to be fearful of DIY. Some farm houses I saw had the kitchen in a separate building; that was their fire insurance.

Alan Brooks,
North Mackay, Qld.

Comparing instantaneous gas with off-peak electric hot water

I must agree with Geoff Syme (Mailbag, March 2013, page 5) regarding losses from storage hot water systems.

I have recorded my gas, electricity and water usage every month since 2007. In May 2012, I replaced my 25-year-old storage gas hot water system with an instantaneous gas system. Since then, my gas usage has consistently been about 14MJ/day lower than for the previous year. Since my hot water, cooking and heating usage pattern have not changed, the excess energy must be the heat loss from the storage hot water system. This is 14MJ/day or about 4kWh/day.

I pay 1.65 cents/MJ for gas, so storage heat loss costs 23 cents per day. If you do the equivalent calculation at 10 cents/kWh for off-peak electricity, the cost is 40 cents per day. Thus off-peak electricity cannot compete with gas in Melbourne.

Since the savings in the instantaneous gas system is less than $50 per year, it will take 20 years to repay the additional cost of the instantaneous gas system. It's hardly worth the additional expense but I do feel a bit greener!

Peter Kay,
Dromana, Vic.

Comment: so gas systems must still have significant losses, whether they are storage or instantaneous. We assume that your previous gas storage system had a pilot light (a small permanently-lit flame, for those not familiar with gas heaters). That would have been responsible for at least some of the losses and losses up the flue to the outside air would also be significant. Both of these are not factors in electric off-peak storage systems. Losses in electric systems involve the wiring, the tank and pipes, although losses in the pipes would be the same in gas systems.

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Mailbag: continued

Changeover to LED down-lights does not need an electrician

I recently read the article on changing 12V halogens to LED down-lights. I do not think there is any doubt that the author of the article is espousing the cost benefits of replacing 12V halogen down lights with LED down-lights. The article goes into some detail indicating the likely savings of using such technology. However, the argument is at best incomplete and possibly misleading.

There is no question that the power usage of LED lights will be significantly less than their 12V halogen counterparts and therefore result in a reduced on-going power bill for the building.

But the article does not address the capital cost of changing over from one type to the other. I am not aware of the various state rules but would not be surprised if by law the replacement of one type with another could also involve the costs associated with a qualified electrician. As a result, how can any reader assess the likely Return on Investment (ROI) time period without a substantial level of effort to fill in the "gaps" within the article?

Unless it was the intention of the article to only provide half a story, it may be worthwhile if the other aspects of the changeover costs are addressed in a future instalment.

Ian Faulder, via email.

Comment: since 12V halogen lamps are normally a plug-in installation, we would take the view that an electrician does not have to be involved since the fixed wiring does not need to be changed or modified. Of course, if the halogen lamps are permanently wired in, then an electrician would need to be involved. Also if a home-owner is unable or unwilling to cut the larger holes for the LED down-lights then it would be appropriate to have an electrician do the job.

Still, it would be a simple matter to have an electrician quote for the job and then return on investment can be calculated.

bill had usage of 403kWh for 87 days (off-peak electric hot water). That's the total, including any losses. So consumption is 4.63kWh/day and cost was 51 cents/day (including GST). The previous quarter's consumption was 468kWh for 91 days. The exterior of the tank is cool to the touch so tank losses must be fairly low.

DAB+ tuner kit & AM reception

I am a retired ex-Telecom Technical Officer and many years ago, in what now seems a previous life, I used to avidly read the electronics magazine of the day, "Radio Television & Hobbies" in its various iterations. I constructed various items of interest, such as the lovely Playmaster 60/60 Stereo Amplifier designed by a Leo Simpson & John Clarke. Then that magazine folded and I lost interest in all things electronic.

Just a few years ago, when I was aged about 60-odd, I attended The Royal Melbourne Institute of Technology and did an "Advanced Electronics" course over two years as I wanted to understand the changes that were taking place in the electronics world and around that time, I discovered SILICON CHIP. Recently, I decided I would build myself a DAB+/FM tuner to add to my Cambridge Azur 620A V2 amplifier and 620C V2 CD Player which I play through my Mission M35i Speakers. (I also have a DVD player and PVR).

I searched on-line and I found your articles on a "A High-Quality DAB+/FM Tuner" by Mauro Grassi (October, November & December 2010) and decided to send for the three issues. I was wondering if you are you contemplating any newer DAB+ tuners in the near future?

Also, I have been wondering about the current situation regarding wideband AM tuners. I am appalled at what constitutes AM sound these day in radios and FM/AM tuners. I realise that stereo AM is no longer with us but would it be possible to do an article on the matter of AM sound today and maybe a half-decent tuner?

I would like to read an article on the Australian scene as it stands today. By that I mean what is the usual AM station bandwidth these days? It sounds like it is generally pushed out to about 4-5kHz bandwidth and seems to have around 10% harmonic distortion, making broadband out of the question. Or are some "music" stations pushing out a wider bandwidth?

Years ago, I actually built a wideband tuner and it had splendid full sound. Unfortunately, I lost it in a house fire. I think the one that I built had around 9kHz bandwidth. I would love to replace it.

My congratulations on your excellent magazine.

Bram Taylor.
Rosebud, Vic.

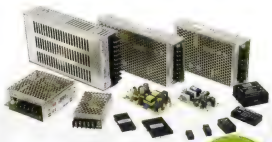
Comment: we have no plans to do another DAB+ tuner as there is little we could do to improve the first design. In any case, it wasn't very popular, regardless of its good performance. Also DAB+ quality is nowhere near as good as it could be because the stations simply do not have a high enough data bit rate.

AM stations still have a bandwidth out to 9kHz and distortion is quite low but very few tuners can exploit the quality available and of course, few stations transmit music. In any case, if you have DAB+ reception, you can receive all FM, AM and ABC & SBS digital radio broadcasts at reasonable quality.

In January 2013, we reviewed the Marantz NA7004 DAB+/AM/FM tuner which features the CS4398 DAC chip and it is a good all-round performer although the FM reception is not up to the very fine standards of the best FM tuners from 30 years ago. Its AM reception is not wideband.

Low voltage DC domestic distribution has drawbacks

I don't think that there is much to recommend Bob Lions' plea for a standardised low voltage distribution system (Mailbag, page 10, Feb-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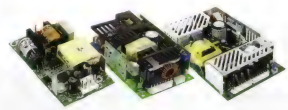
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Mailbag: continued

Doubt on wind farm health issues

Your recent Publisher's Letter titled "Wind farms are now recognised as a serious health issue" (March 2013) will certainly generate some interest. However, you should definitely quote sources to make such a statement.

I am no expert but I do remember many instances where people read something like this on other matters and suddenly discovered they were a victim/sufferer too.

Remember the RSI (Repetitive Strain Injury) discussions in the 1980s, apparently a very serious issue at the time, mostly suffered by employees in the public service and large corporations? It does not seem to be an issue any more, even though computer/keyboard use would have increased by a substantial amount since that time.

The other chestnut of course is radiation from mobile phone base stations. I thought we had put that one to bed too, until recently. There is now quite a kerfuffle going on about an antenna at Balgowlah, in Sydney. Nobody in authority seems to point out that the location in question is not far from a TV translator operating in the same spectrum and transmitting several kilowatts; likely to produce similar field strength at the same spot where residents are concerned. And it has done so for more than 20 years, 24 hours a day, 7 days a week.

It even looks a bit like a phone tower . . . just bigger!

The Publisher seems to be quite vocal in denigrating any "green" initiatives and that is of course his prerogative. I find it strange, however, that this has evolved into such a partisan issue over the last few years. Conservatives seem hell bent to not only dismiss climate science but actively encouraging people to think it is not an issue.

The only only valid reason I can see for not acting at this point in time is that it may already be too late and we will all be dead before the consequences of inaction become fully apparent.

We now have wonderful technology to produce non-polluting power if we choose to use it, but all the noise is about the "Carbon Tax" without any thought being given as to what it aims to achieve. Wind power is obviously not the perfect solution but is only one of many alternatives available.

Your headline is alarmist and provides another argument to those sceptical of climate science or unwilling to debate the issue rationally.

Would it not be more productive if you used your voice to compare different technologies and how they may help achieve a cleaner environment?

Horst Leykam,
Dee Why, NSW.

ruary 2013). There are very few devices that would directly accept the distributed voltage, a point which Bob implicitly recognises when in suggestion (2) he asks for "a series of high efficiency regulators". All that would happen is a swap from readily available 230VAC plugpacks to rarer, and very likely more expensive, 24V regulators. And the system would not be suitable for many domestic appliances like washing machines, so a parallel 230VAC supply is still needed.

Perhaps a nominal 230V DC system would make more sense. Many devices now run off switchmode power supplies and the first thing they do is take the AC mains and rectify it to DC. These might run quite happily from a DC supply with no modification or at most bypassing the bridge rectifier which otherwise would have two diodes carrying all the current instead of sharing it between four. This would have to be considered on a device by device basis but I think that computers, phone chargers, various plugpacks, TVs, CFLs, some dishwashers and washing machines would work.

Toasters and jugs would probably work but would arc badly when they switched themselves off. Many motor-driven devices could not be plugged in directly but may work with "modified" AC, ie, a 50Hz square-wave from a simple controller added to the device or deployed at a convenient 230V DC outlet.

I have considered something like

this in relation to my own electricity usage. A bank of 19 12V 100Ah batteries would supply between 238V fully charged, down to 222V when partially discharged. This is well within the specification of most switchmode supplies. The maximum capacity is nearly 23kWh and my daily consumption averages around 7kWh/day. If these were charged overnight at the cheapest rate, the average charge/discharge would be only 25% of capacity, as some of the 7kWh is being drawn at the night rate so doesn't need to be stored.

Note that it would be necessary to add a series regulator to the distribution system as the battery voltage would be near 270V during charging. This doesn't need to be anything special – a drop of 30V in a resistive load to get 240V is still 87% efficient, and it only happens during charging when most household consumption is minimal.

Economically the figures are not good. The cheaper deep-cycle batteries this size are around $200; an outlay of $3800. If all my electricity was charged at the cheapest rate, rather than the current three-tier rate, I would save approximately $300/year. This is a payback period greater than 12 years at 100% efficiency. It seems unlikely the batteries would last the distance, even though the charge/discharge is low.

If I went off-grid, the situation would improve. My usage would easily be covered by 3kW of solar panels (I have a 1kW system that yields around 1400kWh/year or approx 4kWh per day). By going off-grid I save the static supply charge of approximately $270/year. If the panels have a lifetime of 25 years, the supply charge saved is nearly $7000 and the panel outlay is currently half this.

Conveniently, 3kW of 24V 250W panels has a series output greater than the 270V required for charging the batteries, so a simple MPPT controller would handle it. For bad weather backup, a small, efficient standby generator would also be required. This would still yield a surplus of some thousands of dollars over 25 years.

So economically, battery life is the sticking point. I calculate that being off-grid would cost a few hundred dollars extra per year. As I am currently getting a generous feed-in tariff, this is all speculation at the moment. However, it gives credence to the Publisher's Letter in the December 2012 issue and his comment that going off-grid could be economic with rising tariffs.

Which comes back to the idea of circulating a nominal 230V DC. Obviously some devices just won't work and it would be necessary to feed them with a generated 230VAC. This may not be so costly, with devices like the one used in the Induction Motor Controller (Silicon Chip, April & May 2012) available. Also the technology used in 24V DC/230VAC inverters should translate easily to 230V DC/230VAC, with better efficiency. There are some drawbacks to DC, eg, more arcing and electrolysis problems, to name two. But prompted by Bob Lions' letter, I thought I'd put forward an alternative.

Alan Cashin,
Islington, NSW. SC

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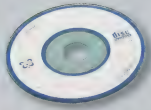
How to get Digital TV on your laptop or desktop PC

By JIM ROWE



Do you want to catch up with TV programs while you work but don't have the space for a TV in your office or den? Now you can watch on your PC, either in a window or full-screen. All you need is a cheap USB DVB-T dongle. But while they are cheap to buy, they can be a bit tricky to install. Never fear though, we take you through the steps to get it done.

YOU MIGHT HAVE written off those el-cheapo DVB-T dongles you've seen on offer from a multitude of on-line sellers. Or you might have bought one and then been thoroughly frustrated trying to install it – we can well understand that! But they are worth the trouble because not only can you watch digital TV on your laptop or desktop PC, many of them are also capable of letting you receive both FM radio and DAB+ digital radio broadcasts.

Even more amazing, most of them are also capable of turning your PC into a wideband VHF/UHF multi-mode communications receiver with a built-in spectrum analyser! They really are a marvel of modern solid-state technology – effectively a digital set-top box shrunk down into a dongle.

In this first of a short series of articles, we're going to explain what's inside those DVB-T USB dongles or "TV sticks" that have almost exploded into the on-line market over the last year or two. We'll also tell you how to put them to work – turning your PC into a DTV receiver plus a DAB+ digital radio and an FM radio, using the software that usually comes with them.

Then, in the next article, we'll explain how to use them with other software to turn your PC into an even more powerful "software defined radio" (SDR), capable of both multi-mode reception and "panoramic" spectrum analysis display over a wide range of VHF and UHF bands. Did you read our review of the WINRADIO communications radio in the June 2012 issue? A software-defined radio using

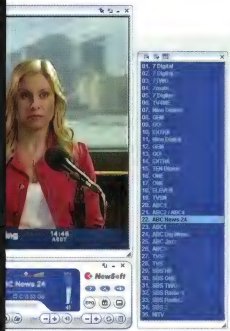


Fig.1 (above): a screen grab of Presto! PVR displaying HDTV channel ABC News 24, received using an ExTV645 USB DVB-T tuner dongle plugged into a Windows XP machine.

Fig.2: three typical DVB-T tuner dongles. These all feature a 75-ohm Belling-Lee antenna socket but many other dongles come with a much smaller SMB connector, requiring an adaptor cable to connect them to an external antenna.

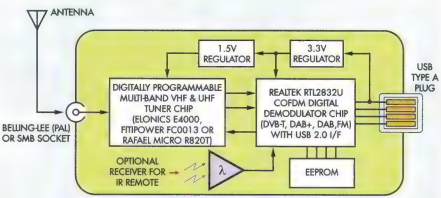
a DVB-T dongle can provide many of the same facilities at a piffling fraction of the cost!

What's inside?

Have we aroused your curiosity? Then let's begin by looking inside a typical dongle to see what's there. As you can see from the block diagram of Fig.3, there isn't all that much. Just two complex chips which do most of the work, plus a few smaller devices which do auxiliary functions like supply voltage regulation, storage of control parameters and receiving IR remote control commands.

In many ways, the heart of these dongles is the digital demodulator chip. In almost all of the dongles currently available, this is an RTL2832U device made by Realtek in Taiwan. A surprising amount of circuitry is crammed inside this tiny 48-pin QFN SMD, as follows:

- A digital demodulator capable of demodulating a wide range of COFDM (coded orthogonal frequency division multiplexing) signals, including DVB-T television (HD and SD), DAB/DAB+ digital radio and analog FM radio. The demodulator supports multiple intermediate frequencies (IF) of 36.167MHz, 4.67MHz and "zero IF" (baseband). It also has automatic transmission mode and guard interval detection, impulse noise cancellation,



INSIDE A TYPICAL DVB-T/FM/DAB+ USB DONGLE OR 'TV STICK'

Fig.3: inside a typical DVB-T USB tuner. It's based on two complex chips: a digitally-programmable multi-band tuner chip and a digital demodulator chip with an IR port and a USB 2.0 interface.

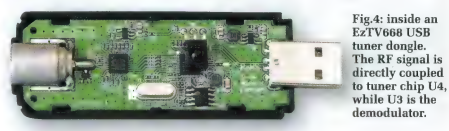


Fig.4: inside an EzTV668 USB tuner dongle. The RF signal is directly coupled to tuner chip U4, while U3 is the demodulator.

delayed AGC, automatic carrier recovery over a wide offset range, a 7-bit ADC for IF signal level measurement and built-in hardware MPEG-2 PID filters;

- A complete USB 2.0 interface engine, supporting full and high speeds with configurable VID information via the external EEPROM; and
- An IR port for remote control and wake-up protocols.

The RTL2832U runs from a 3.3V supply, so it needs a regulator to derive this voltage from the PC via the USB input. Apart from that, all it needs is a single low-cost 28.8MHz crystal and a small EEPROM that's used to store its control parameters and ID configuration data.

The other main chip inside the dongle is a digitally programmable multi-band VHF/UHF tuner chip, shown to the left in Fig.3. This performs all the functions of a complete RF front-end, including a wideband low-noise input amplifier (LNA) with variable gain and autonomous automatic gain control (AGC), a mixer using a fractional-N synthesiser with a fully integrated VCO and loop filter, and a flexible IF amplifier and channel filter with digi-

Fig.5 (below): this Kaiser Baas KBA010003 DVB-T kit comes with the USB tuner itself, a basic infrared remote control, an external whip antenna, a USB extension lead and a software CD.

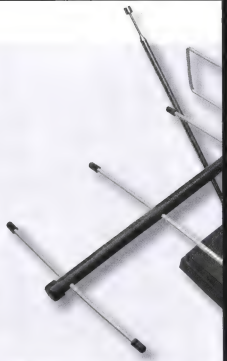


Fig.6: a compact Yagi antenna like this indoor unit may be all you need to get good reception in very strong signal areas. In most cases though, you will need to connect the tuner to a good outside antenna.

tal IF gain control and programmable channel bandwidth.

Tuner chips

There are three different tuner chips used in the vast majority of DVB-T dongles currently available: the E4000 made by Elonics Ltd, the FC0013 made by Fitipower and the R820T device from Rafael Microelectronics in Taiwan. The main differences between these tuner chips seem to be in terms of tuning range and supply voltage, as follows:

- The E4000 operates from 1.5V and covers a tuning range from 52MHz to 2200MHz, with a gap from 1100MHz to approximately 1250MHz;
- The FC0013 operates from 3.3V and covers a tuning range from 22MHz to approximately 1100MHz; and
- The R820T operates from 3.3V and covers a tuning range from 24MHz to 1766MHz.

As you can see, the E4000 has the widest tuning range but its manufacturer has apparently gone out of business. So while you will probably be able to get dongles with this tuner chip for some time to come, these are likely to "dry up" when the dongle makers' stocks run out. Once this happens, dongles containing the R820T tuner chip will probably become the most popular but note that for the kind of DVB-T/DAB/DAB+/FM work that most dongles have been designed for, the FC0013 chip is capable of doing everything that is needed.

Now that you have a reasonable idea of what's inside a typical dongle (from Fig.3), turn your attention to the picture of Fig.4. This shows the inside of an EzTV668 dongle, currently available on-line for less than $30. The PAL/SMB antenna input connector is at left, with the RF signal coupled directly into the E4000 tuner chip (U4) just to its right. If you look closely, you can also see an SOT-23 dual-diode "overload protection" device (labelled U7) just below the centre lug of the PAL connector.

Above the tuner chip you can also see the 1.5V regulator chip (U1) used to provide it with power. Then at lower centre you can see the 28.8MHz crystal used in the clock oscillator of the RTL2832U demodulator chip (U3), which is roughly midway between tuner chip U4 and the USB type A plug at the right-hand end. Note that U3 is partly obscured by the IR remote receiver (U6), the leads of which mount on the PCB above U3, but bent over so the IR receiver is "looking" upwards.

The remaining components to note are the EEPROM (U5), visible just below U3 and U6, and the 3.3V regulator U2, located near the USB plug at upper right.

Most of the dongles you'll currently find on the market will look very similar inside to the one shown in Fig.4. For example, the EzTV645 is almost identical apart from using an FC0013 tuner chip and as a result not having a 1.5V regulator chip. This is also the case with many of the sub-$20 "no-name" dongles and the compact Kaiser Baas KBA01008 (RT). Some of the sub-$20 dongles also lack the IR remote receiver.

Now although they all contain much the same innards, dongles can vary quite a bit in terms of external size. Dongles like the EzTV668 and the EzTV645 are among the largest, measuring about 87mm overall in length, 28mm in width and 17mm in depth. The Kaiser Baas KBA01008 is significantly smaller, measuring 65 x 20 x 13mm, while some of the "no-name" dongles are somewhat smaller again at around 58 x 22 x 10mm – much the same size as an older thumb drive.

Inside the box

So what can you expect to find inside the box, when you order one of these mini marvels and it finally arrives? Well, this can also vary quite

Fig.7: the BlazeVideo HDTV player displaying ABC1 on a laptop with a Digital Energy USB tuner.

a bit, depending largely on how much you've been prepared to spend.

If you have spent $50 or more, you can expect to get a package containing all of the items shown in Fig.5. As well as the dongle itself, there should be one of the baby whip antennas shown, with a coaxial lead about 1.5m long fitted with a PAL or SMB plug to mate with the dongle's antenna input. There will also probably be a small (playing card sized) remote control like the one shown, and perhaps a small USB extension lead like the one visible at upper right.

Most importantly, there should be a CD-ROM with the drivers and software you'll need to install the dongle on your PC. The CD should ideally be a standard 120mm type like that shown (although probably in a paper sleeve rather than in a CD case), as these are suitable for all kinds of CD and DVD drives. But some come with the software on an 80mm CD and these can be tricky to load into a PC with a vertical-tray drive. You may have to copy the files over to a 120mm disk to get around this problem.

Of course you probably won't get all of the above items if you go for a cheaper dongle. For example, you may not get a USB extension lead or a remote control. You may still get one of the baby whip antennas but these are not much use anyway. For best results with virtually any dongle, you need to connect it to a decent outdoor antenna.

With some of the really "el-cheapo" dongles, you may not get even a CD with the software. Instead, there may be just a small card in the box, suggesting you download the software yourself from the website URL they provide. And if the software you can download includes a multi-mode DTV/DAB application as well as the drivers, the card may also be printed with the serial number you'll need to key in to enable the application once it's installed.

Regardless of whether you go for one of the complete kits like that shown in Fig.5 or one of the no-frills sub-$20 specials, the main items you're going to need are the dongle itself and the software. So if the software isn't included, download it and burn it to a CD as soon as you can. The baby whip antenna can be junked unless you plan to use the dongle to watch DTV or listen to DAB+ digital radio with your laptop out in a park with a good line-of-sight to the transmitter antenna towers. Indoors, you'll get the best results using an outside antenna – either a standard TV antenna or a wideband omnidirectional VHF/UHF antenna like a "discone".

Installation

Now let us move on to discuss installing your dongle's drivers and application software on your PC. As you might expect, the first step is to install the driver files, which allow Windows to exchange data and commands with the dongle via the USB port it's connected to. Once the drivers are installed and set up, you can install the application software.

Installing the drivers can sometimes be tricky, as we can vouch for from personal experience. All kinds of strange problems can crop up during the driver installation stage and it can be pretty frustrating. To avoid these problems, we suggest that you follow this procedure:

(1) If you did not receive a CD with

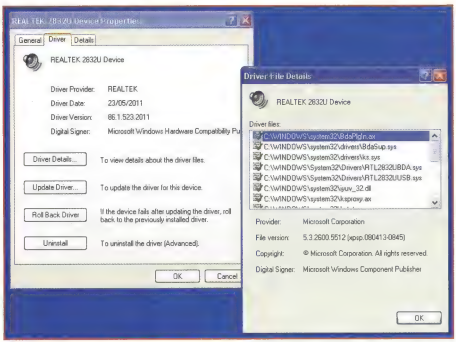


Fig.8: this screen grab shows several of the files that appear in Device Manager when you install the driver software for a DVB-T tuner with a Realtek 2832U chip (almost all such tuners use this chip).

your dongle's drivers and software, go online and download them from the website shown on the card or leaflet. The files will probably download in a single compressed (zip) file. Once this has downloaded, extract the files and burn them to a CD. If one of the files is an installer or autorun file, make sure you burn that to the CD as well (even if it's on a sub-directory).

Alternatively, you can simply save the files into a folder on the hard disk.

(2) Next, plug your dongle into one of the USB 2.0 ports of your PC. Make sure that the port you use is directly associated with one of your PC's USB host controllers; not one of the downstream ports of a hub. The dongle should also be plugged directly into the port if this is at all possible, not via an extension lead. If you must use an extension lead, use a very short one – no longer than about 300mm.

(3) A few seconds after you plug in the dongle, Windows should announce that it has recognised a new device and it will probably fire up an installation "wizard" to find and install what it "thinks" are the correct drivers. Because they almost certainly won't be the correct drivers, don't let the wizard spend a lot of time wandering around on the web searching for and then installing some make-do drivers.

In fact, it's quite OK to click on the wizard's Cancel button, to send it back to sleep. Don't worry if it does manage to find and install some drivers, though – these can be replaced with the real ones later. So just ignore any messages it may display, whether they're advising of an installation problem or of a supposedly successful one.

(4) Now insert the driver disk you received with the dongle (or burnt yourself) into the CD drive of your PC. If it has an autorun file, Windows should run this and present you with a menu listing the various installation options. Make sure you select the "Driver installation" option first, whereupon it should proceed to install the correct drivers for your device.

Provided there's an autorun file, the procedure will be the same if you download the software yourself and burnt the files to a CD. Alternatively, if there's no autorun file and you've saved the files to a CD or to a hard disk, check the files (using Windows Explorer) and double-click the one that looks to be the driver installer. It will probably be an "exe" file, perhaps with the characters "RTL2833U" somewhere in the filename, and it may be in a separate folder on the disk.

When you find the most likely suspect, try running it as the Administrator. This is especially important if you're trying to install the dongle files on a Windows 7 machine.

(5) Once the correct driver files have been installed, exit from the CD autorun menu if there is one, or otherwise simply eject the CD from its drive and place it to one side for the time being. That's because you need to check the status of the driver files yourself, before proceeding to install any other software. There's no point in installing the other software unless the drivers have been correctly installed.

(6) Now click on Start -> Control Panel -> System -> Device Manager and click on the Hardware tab. You should now be presented with a drop-down list of all of the hardware items in the PC that are recognised by Windows. And if you look down this list, you should see a subsection just below Processors, with a [+] sign next to a small loudspeaker icon and the label "Sound, video and game controllers".

Click on the [+] sign to see a drop-down list of devices. Somewhere on that list, there should be an item with a name like "REALTEK 2832U Device" or "DVBT/Radio TV Stick".

(7) Right-click on this item and select "Properties". A window should open displaying the properties of the device. At first, it will probably be displaying its "General" tab, indicating that the device is working correctly. Then, if you click on the "Driver" tab, you should be able to see the Driver Provider as "REALTEK" – as shown in the centre of Fig.8.

(8) Next click on the "Driver Details" button, which should bring up yet another window like that shown on the right in Fig.8. If the driver files have been installed correctly, this window will have a scroll-down list of at least four driver files, with filenames like this: BdaPlgln.ax, BdaSup.sys, ks.sys (or ksthunk.sys), RTL2832UBDA.sys and RTL2832UUSB.sys.

Note especially the "RTL2832U" sequence in two of the files. By the way, there may be other files besides these four – as many as 19 files in all – but that's not important. If those four crucial files are shown, the drivers for your dongle have probably been installed correctly.

(9) If your dongle has an IR remote receiver inside (like the one pictured in Fig.4), its driver software may include another driver file to allow this to be used. In this case, you should also be able to find a "USB Composite Device" listed down near the bottom of the main drop-down list in Device

Manager, under the Universal Serial Bus Controllers section label.

If you right-click this device name and select Properties, you should see in the General tab a message to the effect that it's working correctly. Which is fine but not much consolation if the dongle's main driver files haven't installed properly.

Troubleshooting

So what DO you do if these main driver files are not shown? As you have probably guessed, this almost certainly means that the drivers have not been installed correctly – despite what Device Manager may be telling you. In other words, you are now in troubleshooting territory.

The first thing to try is to unplug the dongle from the USB port, wait a few seconds and then plug it into another USB port. Then wait a few seconds again, while Windows does its stuff and hopefully this time correctly installs the drivers.

When you go into Device Manager again and check the dongle's Properties and driver file details as before, the four critical files listed in point 8 above should now be listed. (Don't ask why changing USB ports can solve the problem, but sometimes it does).

If this doesn't meet with success, the next step is to try re-installing the drivers all over again from the dongle's software CD. In other words, jumping back to step 4 above – but with a few further steps along the way. You'll almost certainly find that the driver installer on that disk will want to uninstall the existing drivers first. It will then get you to reboot the PC before it will agree to install them again.

So what sounds like a simple re-install procedure becomes a bit more complicated. Sorry, but we did tell that these things can sometimes be temperamental to install! Hopefully, you should only have to uninstall, reboot and then re-install the drivers once, before you are greeted with all the correct entries in Device Manager -> Properties -> Driver Details, to confirm that the drivers are finally in place.

Unfortunately, there is still a possibility that even a re-install from the CD won't achieve a successful driver installation. If that's the case, your only option is to find the website of either the dongle maker or their associated software producer and search for a new and/or updated copy of the drivers.

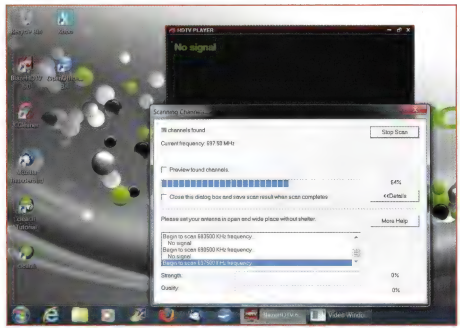


Fig.9: BlazeVideo HDTV scanning for TV channels. This scanning procedure must also initially be carried out for DAB+ and FM radio stations.

Fig.10: BlazeVideo HDTV playing DAB+ radio station 2DAY. Stations can be selected using either the electronic program guide (EPG) dialog, the control panel dialog or the dongle's IR remote control.

Then you can download these drivers, burn them to a CD and begin the driver installation process all over again, from step 4 above. It's a bit of a hassle but it may well be your best chance of finally getting a successful driver install.

The main software app(s)

As explained earlier, there's no point in even trying to install your dongle's main application software until the drivers are correctly installed. But once this has been done, you can re-load the software CD in your PC's disk drive and proceed to install the application software.

You should find this process all relatively straightforward, although you'll probably find that each software application will want you to type in the serial number or password

Fig.11: a live TV screen grab from ArcSoft TotalMedia 3.5 while tuned to ABC News 24, Channel 16.

Fig.12: ArcSoft TotalMedia tuned to DAB+ radio station 702 ABC Sydney (channel 43).

printed on the disk sleeve or download instruction card, as part of the installation process – the usual rigmarole, in other words.

There are several different applications commonly supplied with currently available DVB-T dongles. For example, many EzTV dongles come with NewSoft Presto! PVR, which allows scanning the various bands, viewing DTV, listening to DAB+ or FM radio and also recording DTV to hard disk. Another commonly supplied application is Blaze Video Magic 3.0, which allows you to do video and audio file conversion.

The Kaiser Baas KBA010003 dongle comes with a single application called ArcSoft TotalMedia 3.5, a very powerful app for scanning the DVB-T, DAB+ and FM radio bands, logging all the carriers/stations and letting you view and/or listen to any desired signal. It also allows you to record the signal to hard disk and view any EPG that may be available, etc.

Many of the low-cost, no-name TV dongles that don't come with a driver/software CD but instead ask you to download them yourself provide another application called BlazeVideo HDTV Player 6.0. This seems to be a somewhat later application than Blaze Video Magic 3.0, with various extra bells and whistles (including most of the functions of Presto! PVR). It can also be used to upgrade Blaze Video Magic 3.0, by the way (you just have to "unlock" it using the original serial number/password).

These applications all seem to be capable of giving good results with each of the dongles I have tried, providing each dongle has had its correct drivers installed. However, we should warn you that even with the drivers correctly installed, you can still get some weird problems.

For example, after I installed the drivers for the Kaiser Baas KBA010003 dongle on my Windows 7 machine, checked them and then installed ArcSoft TotalMedia 3.5, it initially couldn't find the dongle and refused to proceed. Only when I went through the rigmarole of uninstalling the drivers and then re-installing them again would it find the dongle when I plugged it in and then go ahead and scan the DVBT, DAB+ and FM channels, etc.

Another problem appeared when installing a no-name dongle on the same Windows 7 machine, using a driver and software file that had to be downloaded and unzipped. The drivers seemed to install correctly, and I could see the correct files when I went into Device Manager -> Properties ->

Use Well-Shielded HDMI or DVI Cables With External Monitors

One thing we soon discovered when experimenting with our DVB-T dongles is that interference radiated from a HDMI or DVI cable can virtually wipe out TV reception, especially if using a small indoor antenna.

In our case, we were using an 80cm TV set as an external monitor for a laptop (fitted with a USB tuner), with the two connected together via an HDMI cable. Because we were in a very strong signal area, the TV set was connected to a small indoor Yagi antenna (as pictured earlier in this article), while the laptop's USB tuner was connected to a simple whip antenna (as supplied).

On its own, the TV set worked well with its little indoor Yagi. Similarly, on its own, the laptop and its external USB tuner worked fine from the simple whip antenna.

However, when we connected the two together via a cheap HDMI cable and fired everything up, the reception was wiped out by strong interference. This occurred regardless as to whether we were using the TV's tuner to directly tune TV channels or whether we were using the TV as a monitor and feeding through signals from the laptop's USB tuner.

In both cases, this problem was solved by using a well-shielded HDMI cable, eg, one with quad-shielding. Using snap-on ferrite sleeves at both ends of the HDMI cable also helped clear the interference when watching the TV.

Using external antennas with good-quality coax may also have solved this problem, since it's probable that the interference from the HDMI cable was being radiated directly into the indoor antennas we were using.

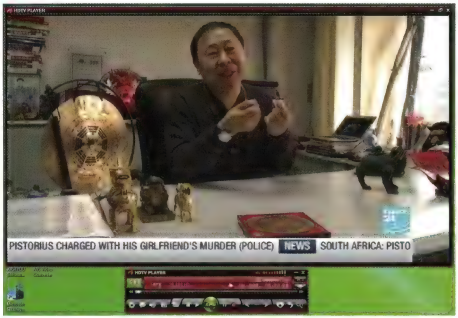


Fig.13: BlazeVideo HDTV Player 6.0 tuned to SBS OneHD on a Windows 7 PC. BlazeVideo is one of the more popular playback applications supplied with USB TV tuners.

Driver Details. Then when I installed the BlazeVideo HDTV Player 6.0 application and started it up, it seemed to scan the DTV channels correctly and I could bring them all up on the PC's screen (either in a window or full screen) – but there was no sound on ABC-24 News or 7-Mate, only a fairly loud hum! And there was no sound at all on GEM.

I tried re-installing BlazeVideo 6.0 again and then getting it to re-scan the channels. When I tried it out again, the sound on GEM had returned but the hum was still there on ABC-24 and 7-Mate.

Another strange problem, this time with my Windows XP (SP3) machine, occurred when I installed the drivers for an EzTV668 dongle and then tried to run ArcSoft TotalMedia 3.5 to see how they would work together. It scanned the DTV channels fine and they were all viewable with their correct sound.

However, when I then instructed it to scan the DAB+ digital radio channels, it couldn't find many of them at all. So I got it to scan the DAB+ band again and then it found them all. Don't ask me why . . .

Success is possible!

Just so you don't get the impression that getting these dongles working correctly on a typical PC is overly difficult, we show a few screen grabs which illustrate that it can be done:

First, Fig.11 shows a grab taken on my Win7 machine running ArcSoft TotalMedia 3.5 and using the Kaiser Baas KBA010008 dongle. It shows the picture of ABC-24 News being displayed in a window, along with the various options;

Fig.12 shows another grab with the same set-up but with TotalMedia 3.3 now receiving DAB+ radio channel 702 ABC Sydney.

For comparison, Fig.1 (on page 12) shows a grab of Presto! PVR receiving HDTV channel ABC News 24 on a Windows XP/SP3 machine, using an ExTV645 dongle. And finally, Fig.13 shows a grab from BlazeVideo 6.0 receiving SBS HDTV on the Windows 7 machine using a no-name dongle.

Hopefully these sample shots will be enough to encourage you to get yourself one or more of these dongles and "give them a go". It can be very worthwhile, despite the risk of hassles if you don't follow the correct procedure.

What's coming?

In the next article, we'll move on to show you how most DTV dongles can be used with different drivers and software, to turn your PC into a true software defined radio or "SDR", capable of multi-mode radio reception over a very wide range of VHF and UHF frequencies – and with a built-in spectrum analyser display. So don't miss it! SC

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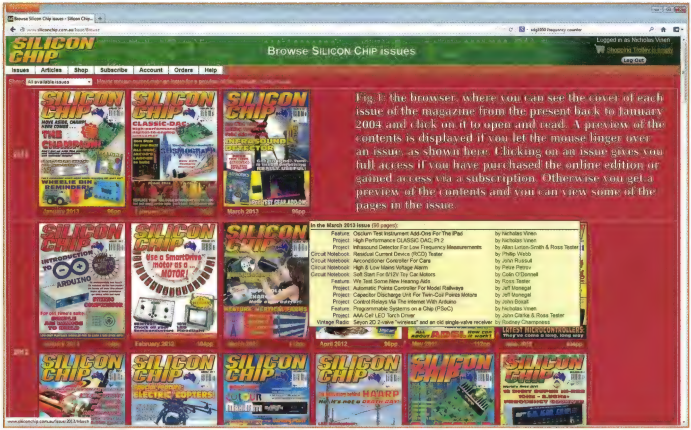

At long last! The Revamped SILICON CHIP Website is here!

After more than 18 months of development, our new website is on-line. It offers page-turning versions of over 100 SILICON CHIP issues, a unified shop with full security and encryption for subscriptions, back issues, PCBs, microcontrollers, books and more, plus the ability to check and update your subscription status at any time.

By NICHOLAS VINEN

OUR WEBSITE has been totally re-built from scratch to add many new features (and improve on old ones). The most important change is that on-line issues are now viewed in a "page-turning" format which means that the magazine appears on-screen exactly as it looks in the printed issue. You now get the full content of each magazine including all the advertisements and you can see all the photos, diagrams and other formatting that we put so much effort into each month.

As well as re-designing the website, we have also taken over its operation and that means we can offer a new range of products and services. For example, current print subscribers can now get on-line access to the same issues by paying a small premium. Our subscribers have been asking for this service for several years and now we can finally provide it. It means you can keep your printed issues at home but get access to them from your office or anywhere in the world, if you want.

Another important benefit of the new website is our integrated shop. The shop includes subscriptions (printed, online and combined), printed and online back issues, PCBs, programmed microcontrollers, binders and some specialised electronic component associated with some of our projects. You can even renew your subscription and purchase items from

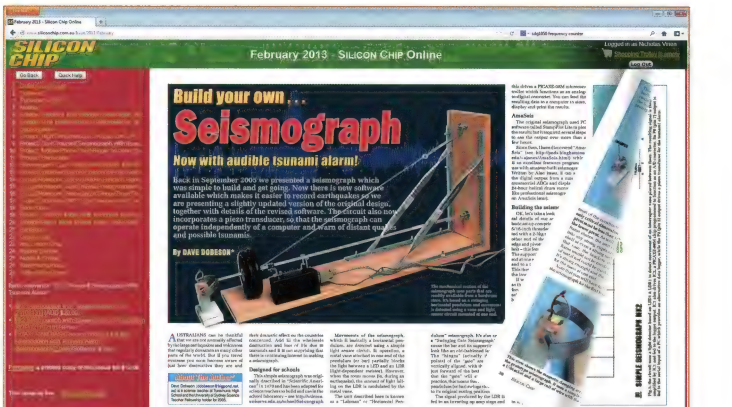

Fig.2: when reading an issue, the contents appear in a bar down the left side of the screen while the issue appears on the right. You can turn the page by grabbing a corner with the mouse cursor and you can also click on an entry in the contents to jump straight to that article. Any shop items or downloads relevant to the article currently on screen are shown below the contents with direct links.

the shop at the same time (and in most cases, that means you will get the 10% subscriber discount on those items immediately).

We should point out that our existing 10% discount to subscribers for back issues, PCBs and so on now applies to active online subscribers as well.

Subscriptions, online payments & shop

You can log in to your online account and check your online and print subscription status at any time. When you renew, extend or upgrade your subscription, the results are immediate. Online issues and online subscriptions purchased using a Visa, Mastercard or PayPal are processed and access is granted straight away. Credit card transactions are processed using SecurePay over encrypted connections and we don't store card numbers for added security.

We also have an online shop, linked to the subscription system, where readers can purchase back issues, on-line issues, PCBs, programmed microcontrollers, books, binders, a limited assortment of difficult-to-get parts and anything else we may sell in future.

Active subscribers get a discount on most items and in most cases, we indicate whether we have an item in stock before you purchase it (or if not, how long you can expect to wait until we get more). Some items, such as printed back-issues, include postage. For other items, in most cases we have a flat rate per order postage charge via Australia Post (airmail for overseas orders).

The main exception is books where a per-book fee is charged due to the extra weight.

Getting a log in

If you are an active print subscriber but have never logged in to our website, as long as we have your email address on file, you can set up your account in a minute or so. Simply visit the website (**siliconchip.com.au**) and click on the "Log in" button in the upper-right corner. You should then see some text under the login fields which reads: ***"If you are an existing print subscriber and don't have a password, click here."***

Click on the "here" and input your subscriber number (five digits, printed on the address sheet which arrives with your magazine each month) and your email address. Instructions will then be emailed to you to allow you to set up a login name and password. Once you've done that, you can view your subscription status (via the ***Account -> Manage My Account*** menu option) and renew at any time.

If you aren't a print subscriber and have never logged into our website (or have logged in to the old website but never purchased a subscription or online issues) then you can sign up for a free account on our new site. It's easy; go to the login screen as above but click on the "sign up" link. Once you have an account you can then order items from the shop and consider getting a subscription.

Reading the online issue

Because the new page-turning format allows you to view the magazine in the same format as the printed ver-

Fig.3: you can find and purchase PCBs, programmed micros and some parts for SILICON CHIP projects in the online shop. You can also subscribe, renew a subscription, order a back issue or online issue and so on. Orders can be paid using Visa, Mastercard or PayPal. Active subscribers receive an automatic 10% discount on most items (subscriptions excluded).

sion, for best results we recommend a high-resolution monitor. Best results will be achieved with a 20-inch or larger monitor with a resolution of 1920x1080 or higher (ideally, at least 1920x1200). For laptops, a 15-inch or larger full HD (1920x1080) display is best although smaller sizes may be acceptable as long as the resolution is still high.

The issue is displayed as a double-page spread (except for the front and rear covers). You can then flip to the next or previous spread by dragging or clicking the corner of the page. Alternatively, you can use the arrow keys or page up/page down on the keyboard.

A list of articles appears in a sidebar to the left of the issue; clicking on an article will jump to its first page and the currently displayed article(s) are highlighted. Holding the mouse cursor over one of these article links shows a short summary of its content.

When reading an online issue, you will get the best display in full screen mode. This can be enabled by clicking the button which appears in the lower-left corner of the screen. With some browsers, you may need to press the F11 key instead. This is especially important on smaller or lower resolution monitors but may be worthwhile for high-res monitors too.

Zooming in

For smaller or lower-resolution screens, it will be necessary to zoom in to comfortably read the text and view diagrams properly. This can be done easily using the mouse wheel or trackpad scroll bar/gesture, which zooms the page into the area the cursor is currently located over. You can then move the pointer towards the edges of the screen to scroll around the issue. Or you can zoom back out using the scroll wheel, then zoom in somewhere else.

Each online issue is available in three resolutions: low, medium and high. The default is "low" because it loads the fastest but if you have a high-res display as recommended you will probably want to turn it up to "medium" or "high". A typical issue is around 20-25MB in low resolution, 35-45MB in medium resolution and 50-70MB in high resolution.

Because the online issues are quite large, we have located our server on a fast internet link (in "the cloud"). If you have cable or DSL, most issues should load in 30-60 seconds. It may take slightly longer during times of high internet congestion.

Because loading an issue takes a little while, if you're going to re-visit it later, you will want your web browser to cache it. Some (such as Internet Explorer) should do this automatically while others (eg, Firefox) have size limits on the files they will cache that may interfere with caching online issues. In our FAQ (**siliconchip.com.au/Help/FAQ**), we explain how to increase the size of objects that Firefox will cache to solve this problem.

Shop links

One of the benefits of integrating the online issues and the shop onto the same site is that when you are reading an article that has one or more associated shop items (PCBs, programmed micros, etc), links to these items appear in the side-bar, below the issue contents. PCB patterns, front panel artwork and software is also kept in the shop (for the moment, these are all free) and so associated downloads also appear alongside the article.

Also, when reading multi-part articles, we include links to the other parts of that article (in other issues) in the same location, ie, below the issue content links. That makes it easy to jump to another part; the required issue loads and then it opens to the first page of that article.

Browser support

Our website has been tested with the latest versions of Firefox, Chrome, Internet Explorer and Safari. We have also done our best to make it work in older browsers as some people are stuck with them. To view the online issues, you will also need the Adobe Flash plugin (which is built into some versions of Chrome). That currently rules out certain devices (but see below about upcoming features). However, for the moment, there is no valid alternative to Flash.

Many sources recommend using HTML5 animation support instead of, or in addition to, Flash however currently, Adobe's software does not support HTML5 fully; their page lay-

out software, InDesign, has the ability to export to Flash flipbooks but not to HTML5 format. Also, HTML5 files are often much larger than the same content in Flash, up to twice the size, and that would mean our online issues could easily exceed 100MB.

Printing

While you can print the online issue, it doesn't currently work terribly well. The problem is that the Flash flipbook treats each double-page spread as if it's a single page. So unless you have an A3 printer, you will have to print in landscape mode and then the result will be two magazine pages on an A4 sheet, resulting in a printout that's about 72.5% of normal size.

That's large enough to be legible but far from ideal. We are working on a better printing option which will hopefully give a full-size printout with one page per page and will release it to all users when it is ready.

PDFs

Some readers have asked for PDFs of issues and we have considered this but are reluctant to produce them. The reason is that there are already quite a few scanned PDFs of Silicon Chip magazines being distributed on Internet file-sharing sites and we're concerned that releasing online issues as PDFs will only lead to a greater incidence of this unauthorised redistribution and other copyright breaches.

That's a great pity because we know that 99.9% of our readers are honest and we understand that having PDF issues can be convenient. So we will continue to consider offering PDFs based on reader feedback and may do this in future.

Tablet/phone support

Currently our website is not designed to work on tablet computers but we are planning to address this, in part at least. The biggest challenge is the small and in some cases low-resolution screens on these devices – zooming in and panning around the content will be virtually mandatory.

Also, many of these devices, including iPads and iPhones and some recent Android devices, do not support Adobe Flash so we will want to come up with an alternative way to view the content. It probably won't have quite as many features as the Flash version but we'd like to offer some sort of alternative viewer for people who can't view Flash content.

Once we manage to do that, we will provide the option for readers to view issues either way, to suit the device they are using. It may even be possible to automatically detect the type of device viewing the website and select the appropriate display method.

Fig.4: once you have created an account on the website, you can subscribe or renew. There are various subscriptions to choose from and if taking out a new subscription, it is possible to select which issue you want to start with. We now offer the ability to upgrade a print subscription to include online access for a small extra fee. It is also possible to check your current subscription status via the website.

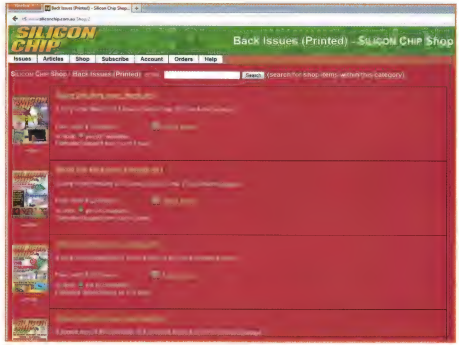

Fig.5: you can also order printed back issues from the online shop. Some older issues are no longer available but in these cases, you can place an online order for a photocopy of a specified article.

Article search

We offer two methods for searching online issues, both of which may be of help to readers who already have a

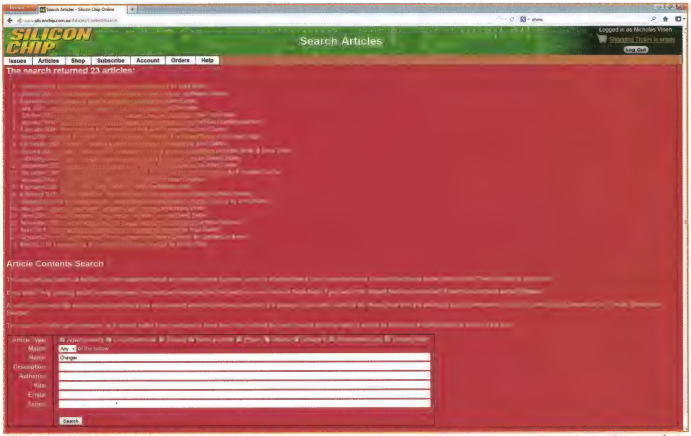

Fig.6: the article content search facility can be used to find a SILICON CHIP article based on the title, author or key words in the description field. This will search all issues back to January 2004 and the results contain links to the online versions of those articles (preview only until the issue is purchased).

considerable catalog of printed issues.

Word search is the simplest. You type in one or more words or phrases and in response, get a list of articles which contain these words, ranked in order with the best matches first. The results give you the year, month, article name and a link to view the online issue (or preview if you haven't already purchased it). The link takes you straight to the article once the issue has loaded. You also get a list of pages on which the words were found.

Content search is a bit more precise but relies on you knowing some or all of the details relevant to the article you are looking for. You can select which type of articles to search (feature, project, etc) and then enter one or more words to look for in the name of the article, description, authors and so on.

So for example, if you know who the article is by but can't remember what it's called, you can quickly call up a list of all articles by that author in order of date and then scan the list to find the one you are looking for.

Legacy site

We didn't want to pull the rug out from under online subscribers who were already used to the old HTML format of the articles so we have preserved the website content up to the date of the change-over (November 2012).

This website is located at **http://archive.siliconchip.com.au** and allows pre-existing users to log in and view content they have purchased. Pre-existing users can also log in and view the same content in the new format on the main website if they wish. This can be done using the same login name (email address) and password as was used originally.

This does not apply for content prior to 2004 as we will not be putting this up in page-turning format.

Note though that the legacy site and new website are separate; the legacy site is a "time capsule". So, for example, if you are a legacy user and change your password on the new site, you will still need to use the old password to get into the legacy (archive) site.

Future improvements

We've already discussed future improvements to printing and to support for browsing using tablets and mobile phones. There are some other areas we are hoping to make improvements to later this year. Some of our ideas for improvements include:

- The ability for searches to return results from older issues which are not available online;
- An option for readers to purchase a year's worth of online back-issues at a discounted price (similar to the subscription rate);
- Automatic email subscription renewal reminders and optional emails to remind subscribers when a new online issue is released; and
- An optional email newsletter which we will send out from time to time regarding upcoming projects and topical subjects

Any other suggestions or feedback from readers are welcome.

Readers are also invited to take a look at the website if you haven't already and consider activating your account (or signing up if you are not a subscriber) to take advantage of the ability to check your subscription status, renew online and order parts if you need any. SC

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LED LADYBIRD

. . . an eye-catching electronic beetle

Be the light of the party with this unique electronic brooch. Or just build it as an interesting novelty piece.

Tired of lacklustre fake precious-stone brooches and ornaments that have no life? Why not build a vibrant electronic brooch or ornament instead? LED Ladybird uses high-brightness LEDs for its eyes, wings and abdomen and it flashes these in a fetching moving pattern. Call it LED animation if you will but it is certainly eye-catching!

By JOHN CLARKE

IF YOU ARE AFTER something different to wear at a party or dance, it's hard to look past the LED Ladybird. Suitably fitted with a clasp, you could wear it as a brooch, or you could attach it to a headband or maybe even use it as an earring or pendant.

Perhaps you could just build it as a fascinating coffee table piece, a school project or an executive toy. Apart from that, it's a great little project for honing your "surface-mount" assembly skills.

So why have we called it a "LED Ladybird"? Well, first, because it's shaped like a real ladybird and second, because it incorporates LEDs. We've taken a few liberties with the colours though. A real ladybird has an orange body with black spots but that's impractical for our electronic version because there are no black LEDs.

As a result, we've reversed the colours, using a black PCB to make up the body and 20 orange LEDs for the spots. Two high-brightness red LEDs are used for the eyes.

We're not too sure what colour eyes a real ladybird has but red looks pretty good in our opinion. Besides, they needed to be different to the orange LEDs used for the spots.

As shown in the photos, the PCB's outline matches the shape of a real ladybird beetle; ie, it's roughly pear-shaped. Along with the LEDs, we've also fitted six wire legs and two antennae to the PCB, to make it more ladybird like. There's also a pushbutton switch to turn it on or off and it's all powered from a single 3V lithium cell slung underneath the insect's belly.

LED sequence

When you turn it on, the LEDs flash in an intriguing and fascinating sequence. This sequence is designed to mimic the flapping of a ladybird's wings, from take-off to landing.

These four diagrams show the basic LED flashing (flying) sequence. First the red eyes come on and the orange LEDs for the right wing flash. The left wing then flashes, then both wings and then all the LEDs flash, including those down the middle. In practice, it's a bit more complicated than that so take a look at the video on our website (see text).

First, the two red eyes come on one after the other (and stay on), then the eight central LEDs (six abdomen and two rear) flash once in a chaser sequence. Once that's completed, the six orange LEDs making up the righthand wing begin flashing, slowly at first then gradually increasing in speed before slowing down again.

These six right-wing LEDs then extinguish and the six left-wing LEDs repeat the sequence, after which both sets of wing LEDs flash together. The eight central LEDs then get in on the act, two at time, with all LEDs on the beetle (including the eyes) then flashing together.

After that, there's some more fancy footwork with the eight central body LEDs entering a chase sequence while the other LEDs all flash at a rapid rate. The unit then goes into a power-down sequence with the central LEDs going out and the wing LEDs flashing at a decreasing rate until they extinguish.

Finally, the eight trail LEDs and the red eyes flash once in a chaser sequence, from rear to centre, after which the two eyes extinguish and the unit automatically powers down.

Alternatively, you can switch the unit off at any time while it is operating by pressing the power switch.

Of course, it's far more interesting when you see it in action. So don't just rely on the written description. Instead, take a look at the video at siliconchip.com.au/videos/ledladybird

Continuous party mode

Normally, the LED Ladybird runs through a single cycle of its entire LED lighting sequence and then automatically switches off to save power. It can be run again at any time simply by pressing the pushbutton power switch.

Alternatively, it can also be set up to continuously repeat its LED lighting repertoire until switched off with the pushbutton switch. This continuous mode setting is ideal if you want to wear the LED Ladybird to a party or use it as a display in a shop window or on a Christmas tree.

Switching the unit to operate in continuous mode is easy – just hold the pushbutton switch down for several seconds when switching on, until the right eye blinks off briefly.

We estimate that the lithium cell will last for about 10 hours when the unit is operated in continuous mode. If you require longer than this, then

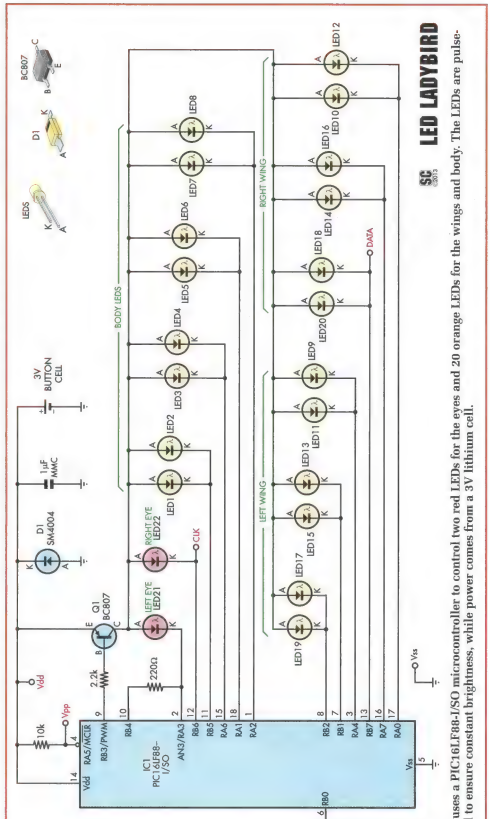

Fig.1: the circuit uses a PIC16LF88-I/SO microcontroller to control two red LEDs for the eyes and 20 orange LEDs for the wings and body. The LEDs are pulse-width modulated to ensure constant brightness, while power comes from a 3V lithium cell.

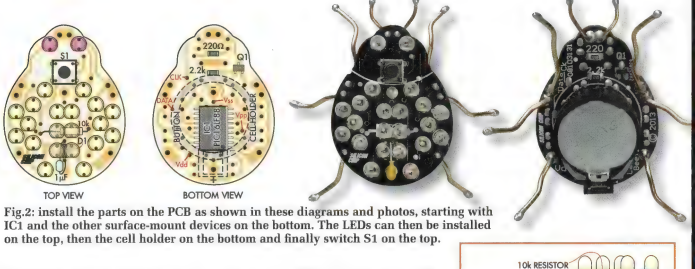

Fig.2: install the parts on the PCB as shown in these diagrams and photos, starting with IC1 and the other surface-mount devices on the bottom. The LEDs can then be installed on the top, then the cell holder on the bottom and finally switch S1 on the top.

the unit can be powered from two AA cells (or any other external 3V supply) connected via a length of twin cable.

Circuit details

Take a look now at Fig.1 for the circuit details. It's really very simple and uses an 18-pin PIC microcontroller (IC1), 22 LEDs and not a lot else. All the clever stuff is hidden inside the microcontroller which is programmed to control the LEDs.

As shown, the 3V supply rail (from a lithium cell or two AA cells) is bypassed with a 1µF ceramic capacitor. Diode D1 provides reverse polarity protection – it conducts and limits the voltage applied to IC1 to just -0.6V should the supply be connected in reverse. This diode is a 1A type if using a 3V lithium cell but should be upgraded to a 3A type if using an external supply (see parts list).

Note that a Schottky diode should not be used here. These have significant reverse leakage and would draw tens of microamps continuously from the cell, flattening it prematurely.

IC1, a PIC16LF88-I/SO, is a surface-mount SOIC low-power version of the PIC16F88. This device can operate down to just 2V. Diode D1, transistor Q1 and the 2.2kΩ and 220Ω resistors are also all surface-mount devices.

IC1's MCLR input (pin 4) is tied to the +3V supply rail via a 10kΩ resistor, so that the micro resets at power-on. Pin 14 (Vdd) of the micro connects directly to the +3V rail, while on/off switch S1 connects between its RB0 input (pin 6) and ground. This RB0 input is normally pulled high to the +3V supply rail via an internal pull-up resistor but is pulled low each time S1 is pressed.

Normally, IC1 is asleep, with its internal oscillator stopped and the microcontroller section not running. This places IC1 in its lowest current draw state. It typically draws 100nA in this mode but we measured just 11nA for our prototype.

Pressing S1 pulls RB0 (pin 6) low. This wakes IC1 and starts the software running. Pressing the switch while IC1 is running places it in sleep mode gain.

LEDs1-22 are driven directly by IC1's output ports, without current-limiting resistors. This was done both to save on the parts count and because there's no space for current-limiting resistors on the PCB.

Driving the LEDs in this way is quite acceptable provided we don't cause too much current to flow in the output pins. In this circuit, the maximum supply voltage is around 3.3V (with fresh cells) and this prevents each output from sinking more than about 21mA. This is within the limits allowed for both the microcontroller's output pins and for the LEDs.

How do we arrive at that figure? Well, the impedance of the output pins is typically 70Ω and there will be 1.8V across each LED when it is on. This means that, with a 3.3V supply, the voltage across the 70Ω output impedance will be 1.5V, so the current through the LEDs will be 1.5V ÷ 70Ω = 21mA.

As the cell voltage falls, so does the LED current. For example, at a cell voltage of 2.2V and with 1.8V typically across the LEDs, there is just 0.4V across the 70Ω output impedance and so the current is just 5.7mA.

That means that the average LED current and hence the LED brightness would be dependent on cell voltage unless steps are taken to prevent this. So, to maintain a constant LED brightness independent of cell voltage, the LEDs are driven with a variable pulse width modulated (PWM) supply.

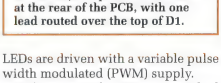

Fig.3: this sectional view shows how the 1µF capacitor is installed at the rear of the PCB, with one lead routed over the top of D1.

In this circuit, the LEDs are switched on and off at a 1kHz rate, with the duty cycle varied to provide constant brightness. At a 50% duty cycle (ie, LEDs switched on and off for equal periods), the average LED current is half that compared to a 100% duty cycle (ie, LEDs switched on all the time). So by varying the duty cycle, we can control the average current through the LEDs.

IC1's PWM output is at pin 9 and this drives PNP transistor Q1. This transistor in turn switches the supply to all the LEDs which have their anodes wired in parallel. This means that the supply to the LEDs switches off each time the PWM signal goes high (Q1 off) and switches on when the PWM signal goes low (Q1 on). The duty cycle is set to produce consistent LED brightness over the cell voltage range from 2-3.3V.

Measuring cell voltage

In order for IC1 to correctly vary the PWM signal, it needs to accurately measure the cell voltage. That's done indirectly by first switching Q1 fully on and taking IC1's RB4 output (pin 10) low to drive LED21 via a 220Ω resistor. The resulting voltage across the 220Ω resistor is then measured by IC1's AN3 analog input (pin 2) and this is then used to calculate the correct PWM duty cycle to drive the LEDs.

This measurement is made at the start of each LED flashing (or flying) sequence (ie, when power is applied or at the start of each sequence if the unit is operating in continuous mode).

Once this measurement has been made, the RB4 output is set as an input, AN3 is set to an output and the PWM signal operates at the required duty cycle. That way, LED21 can now be driven directly by the PWM voltage at Q1's collector and RA3 (ie, the 220Ω resistor is taken out of circuit). This LED is on when RA3 is set low, while the other LEDs turn on when IC1 sets their respective outputs low.

Note that while the two eye LEDs are driven independently, the remaining LEDs are driven as sets of two in parallel. When the circuit is running and flashing the LEDs, the current drawn from the cell averages out at about 8mA.

Above: another view of our prototype LED Ladybird, along with a diagram showing the LED numbering scheme (right).

Building it

OK, let's put LED Ladybird together. As shown in Figs.2 & 3, all the parts are mounted on a PCB coded 08103131 and measuring 43 x 32mm.

Start by checking the PCB for any faults such as shorted tracks and undrilled holes. The PCB supplied by SILICON CHIP Partshop and from the kit suppliers will be double-sided, plated through, solder masked and screen printed. These are high-quality boards and are unlikely to have any defects but it's always a good idea to check.

Having checked the board, begin the assembly by installing the surface mount parts on the underside – see Fig.2. IC1 should go in first. This is an 18-pin SOIC package and it's relatively easy to solder in place due to its 0.05-inch pin spacing. You will need a fine-tipped soldering iron, some solder wick and (preferably) a magnifying lamp to do the job.

The first step is to position the IC on top of its pads, making sure that it is orientated correctly. That done, solder pin 1 to hold it in place, then check to make sure that all the pins are correctly aligned with their pads. Adjust its position if necessary, then solder all the remaining pins, starting with the diagonally opposite pin (pin 10).

Don't worry if you get solder bridges between adjacent pins during this process; they are virtually inevitable. Once all the pins have been soldered, any bridges can be cleared by pressing solder wick against them using the hot tip of a soldering iron. This will soak up the excess solder while leaving the solder joint between the bottom of the pin and its pad intact.

The 2.2kΩ and 220Ω SMD resistors are installed next. It's just a matter of soldering these at one end first, then making sure they are correctly positioned before soldering the other ends. Once they're in, you can install SMD transistor Q1.

Now flip the PCB over and install the 10kΩ resistor. This is a conventional leaded part and it must be installed with its ends cranked slightly as shown in Fig.2. **This resistor must also be offset to the right, ie, the righthand lead must be bent close to the resistor's body.**

This is necessary to ensure that, when the LEDs are later installed, one

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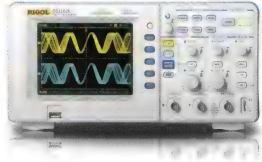

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Parts List

1 PCB, code 08103131, 43 x 32mm (with black solder mask)
1 SPST vertical mount micro-switch with 6mm actuator (Jaycar SP-0603, Altronics S1421) (S1)
1 20mm button cell holder (Jaycar PH-9238, Altronics S5056)
1 CR2032 lithium cell
1 200mm length of 1.25mm enamelled copper wire
1 40mm length of 1mm enamelled copper wire

Semiconductors

1 PIC16LF88-I/SO microcontroller programmed with 0810313A.hex (IC1)
20 3mm orange LEDs, 1700mcd (LEDs1-20)
2 3mm red LEDs, 1000mcd (LED21,LED22)
1 BC807 (SOT-23) surface-mount PNP transistor (Q1)
1 SM4004 1A diode (D1)

Capacitors

1 1µF MMC

Resistors (0.25W, 1%)

1 10kΩ axial lead
1 2.2kΩ SMD 1206 (3216 metric)
1 220Ω SMD 1206 (3216 metric)

Alternative external 3V supply

1 SM5404 3A diode or use an axial-lead 1N5404 across the supply (D1)
1 dual AA-cell battery holder
2 AA cells
1 length light-duty figure-8 wire

LED's lead will straddle the central section of the resistor's body, while the leads of the adjacent LED to its left will be clear of the resistor end cap. That way, the LEDs that straddle this resistor will have their leads clear of the end caps – a necessary precaution to avoid possible short circuits.

Diode D1 (another SMD) can now go in. It must be installed with its cathode end towards the bottom edge of the PCB (ie, towards the rear of the Ladybird). Once it's in, the next step is to install the 1µF MMC capacitor in parallel with this diode. This capacitor will need to have its leads bent so that it sits vertically between LEDs 7 & 8. The top lead is then run across the top of diode D1 (ie, between LEDs 5 & 6) and soldered to the diode end adjacent to the 10kΩ resistor.

You can now install the 22 LEDs. These must be fitted with their cathode leads (indicated by a flat edge on the LED bodies) orientated as shown. Start with the central LEDs, then work your way outwards, as this will make the job much easier.

These LEDs should all be stood off the PCB by about 3mm and this can be achieved by pushing each LED down onto a 3mm-high spacer before soldering its leads. Note that some of the centrally-located LEDs will have to have their leads soldered on the top side of the PCB, since IC1 prevents access to their pads on the underside.

The cell holder is next on the list. This sits against IC1 and must be orientated as shown in Fig.2 and the photos. Push it down onto the PCB as far as it will go before soldering its positive and negative pins. The positive pin is soldered from the underside of the PCB, while the negative pin is soldered from the top.

The parts assembly can now be completed by installing switch S1. This has to be left until last, otherwise it's too difficult to solder the adjacent negative pin of the cell holder.

In-circuit programming

Note that Fig.2 indicates the external connections for Vdd, Vss, Vpp, Data and Clock. These allow a PIC programmer to be connected if you want to program the PIC yourself with software downloaded from the SILICON CHIP website (ie, before the battery holder is installed).

Alternatively, pre-programmed PICs for this project can be purchased from the SILICON CHIP on-line shop and will also be supplied by kit suppliers.

Fitting the legs

The PCB assembly can now be completed by fitting the legs and antennae. Six 25mm lengths of 1.25mm diameter enamelled copper wire are used for the legs, while 15mm lengths of 1mm wire are used for the antennae.

The first step is to straighten the 1.25mm-diameter copper wire by clamping one end in a vice and then pulling on the other end with a pair of pliers to stretch it slightly. That done, cut the wire into 25mm lengths, strip the enamel from both ends of each wire and solder them to the spare PC pads around the edge of the body.

The free end of each leg can then be covered with a solder blob, to form the feet. Once that's done, the two 15mm-long antenna can be fitted in similar fashion. The wires are then bent to shape using needle-nose pliers, as shown in the photos.

Check out

This is the easy part – simply insert a 3V lithium cell into the holder (positive side outwards) and check that the LED Ladybird works when switch S1 is pressed.

If it's working correctly, the left eye LED will appear to quickly come up to full brightness when the cell voltage is around 3V. As the cell voltage drops though, this LED will initially ramp up to a lower brightness before then jumping to full brightness.

Basically, this jump in brightness is small when the cell voltage is close to 3V but gradually increases to a 50% jump in brightness as the cell voltage drops to 2V. This provides some indication of the cell's condition.

Once the LED's brightness has been set (ie, by the micro monitoring the cell voltage and adjusting its PWM signal), the right eye LED will come on and then the flashing LED sequence for the wings will start.

Single or repeat mode

As stated previously, the LED Ladybird is programmed to cycle through its LED flashing sequence just once, then automatically switch off. An entire cycle takes about 1 minute and 20 seconds (80s) but as mentioned, it can be stopped at any time by pressing S1.

If you want the LED sequence to cycle continuously, switch off, then press switch S1 and hold it down for several seconds until the right eye LED blinks off briefly. When you do this, the left eye LED will flash continuously (to indicate continuous mode) until S1 is released.

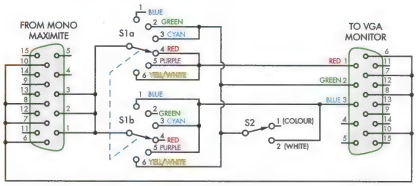
To go back to single sequence mode, switch the LED Ladybird off, then press S1 and hold it down until the right eye flashes.

Attaching the LED Ladybird

The LED Ladybird can be easily attached to clothing by sewing a few cotton loops over several legs. Alternatively, if you are using a lithium cell to power the unit, a strong rare earth magnet can be used to "clamp" the LED Ladybird in position. SC

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



Splash of colour for the regular MaxiMite

If you have already built the original MaxiMite but are tired of white text on a black background or perhaps a bit jealous of the Colour MaxiMite but can't justify the expense of building a whole new unit, this simple modification could be the solution to your problem.

When using the MaxiMite with a VGA monitor, it allows you to change the text/graphics foreground colour at any time to one of seven possibilities; ie, white, red, green, blue, yellow, cyan (green-blue) or magenta.

The display will still be monochrome but at least you can adjust the one available colour to your liking. This is done using one rotary switch (2-pole, 6-position) and one single-pole, single-throw (SPST) toggle switch.

The circuit is very simple. The MaxiMite's video output is connected to the red, green and blue pins on the VGA connector in parallel. Since they are all driven with the same signal, the foreground colour of the display is a mixture of red, green and blue in equal quantities, which gives white.

The two new switches, S1 and S2, are interposed between the MaxiMite's VGA output and the VGA monitor so that different combinations of the three colour signal lines can be driven while the others are left undriven, thus producing a different mixture of the three primary colours for all lit pixels.

With S2 switched to the "colour" setting and S1 in position 1, the MaxiMite's output line is connected to the blue pin of the output VGA connector via S1b and not to red or green, thus giving a blue-on-black display. Similarly, with S1 in position 3, the green output line is connected to the MaxiMite via S1a while blue is also connected via S1b, giving a cyan-on-black display. And so it goes for the other four colours.

Don Grimble is this month's winner of a $150 gift voucher from Hare & Forbes

For white text, all three output colour lines must be driven in parallel, as they would be if the VGA cable were plugged straight into the MaxiMite. To achieve this, switch S1 is set to position six which connects the red and green output lines, while S2 connects the blue line when set into the "white" position.

The switches and DB15 male/female connectors can be housed in a small plastic box and connected in-line with the VGA cable between the MaxiMite and the monitor. If you have room in the box and your VGA monitor doesn't have speakers, you could also consider including a small audio amplifier module, such as the Champion (published in January 2013), along with a small speaker.

Don Grimble,
Marangaroo, WA.

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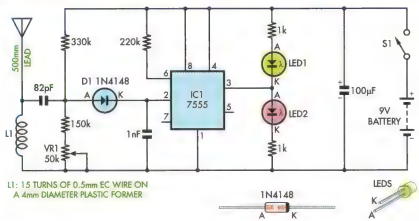


FM bug detector uses a 7555 as a comparator

Here is a simple and sensitive detector that can detect even very low power FM bugs with an output of 30mW or less at a distance of up to four metres, although it must be admitted that FM bugs would not be common these days. It can also help you adjust and peak the performance of a transmitter you have built or just to check and see whether it is producing RF signal within the range of 88-108MHz.

As shown, signal picked up by the 500mm-long lead or telescopic antenna is coupled to the rest of the circuit via an 82pF capacitor. Inductor L1, a 15-turn coil of 0.5mm enamelled copper wire wound on a 4mm diameter former (eg, a 4mm drill bit), forms a broadband trap.

In the second stage, the signal coupled from the antenna is rectified by a signal diode and filtered by a 1nF reservoir capacitor. The signal level is biased to about 1/3rd the supply voltage using a resistive divider formed by two fixed resistors and potentiometer VR1.

The filtered signal is fed to pin 2 of a 7555 (IC1) which is used as a sensitive comparator. It drives a pair of indicator LEDs connected to its output at pin 3.

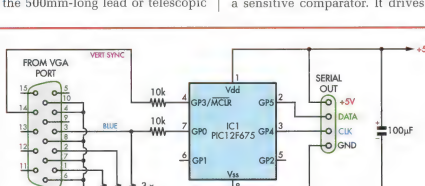
When the voltage on pin 2 is below 1/3rd the supply voltage, the output is high and only LED2 (red) is ON. But as the voltage exceeds this level, the output is taken low, LED1 (green) turns ON and LED2 turns OFF.

To set up the circuit, rotate VR1 to minimum resistance and switch on. LED2 should be on. Now rotate VR1 until LED1 is also partially on; this is the optimal setting. Any RF signal picked up by the antenna and rectified by D1 will then cause the voltage on pin 2 of IC1 to rise slightly, turning LED1 on brighter and making LED2 dimmer.

The detection range will depend on this adjustment. With optimal setting, a low-power transmitter can be detected within the range of four metres.

For the detection of more powerful transmitters, the sensitivity should be decreased by turning VR1 down so that it has less resistance. The other option is to use a shorter antenna. A 300mm long antenna, for example, will decrease the detection range by 50% (the shorter the antenna, the less the sensitivity and detection range).

Mahmood Alimohammadi, Tehran, Iran. ($40)



Serial data transmission over VGA

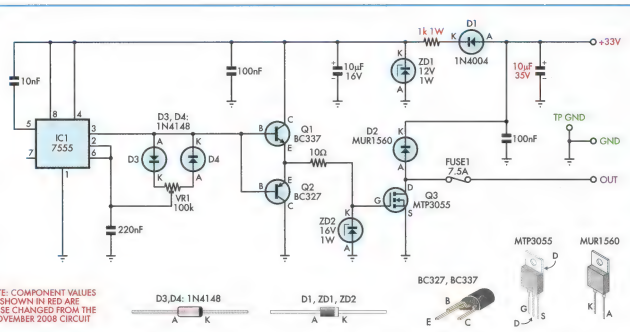
Say you have a computer or microcontroller module with a VGA output but no serial interface and you want to send data to an external device. How would you go about doing this?

One possibility is to encode some serial data into the VGA signal itself. A simple external circuit can then decode this and use it to drive some I/O lines. That is what this circuit and the accompanying software achieves.

The particular application this was developed for is "home automation", where a small computer with a built-in screen can control lights, the air-conditioner, sprinklers etc. Data is encoded in a series of light/dark lines incorporated into the display which is also output on the VGA port. These lines appear just below the title bar of the window. Below those horizontal bars is the main display itself.

There are 18 lines encoding eight bits of data at any given time. A PIC12F675 microcontroller (IC1) monitors the VGA blue signal via its pin 7 input. It detects the vertical refresh (using the vertical sync pulse which is read by input pin 4) and then ignores the window title bar, which must be blue and positioned at the top of the screen (ie, the window should be maximised).

A couple of black lines below the title bar allow it to detect the start of the data. The lines below those two alternate between data synchronisation lines, which are blue and these



Dimmer for Christmas light LED strings

Many Christmas Light LED strings typically work with the supply voltage of about 33V DC. This is fine if you want them to work at full brilliance outdoors at night but if you want them indoors they can be too bright.

This circuit is a variation of the 12V Speed Controller/Lamp Dimmer published in the November 2008 issue of SILICON CHIP and will dim the LEDs to a comfortable setting. As shown, the circuit uses a 7555 timer (IC1) to generate variable width pulses at about 210Hz. These pulses drive Mosfet Q3 via transistors Q1 & Q2 to control the LED brightness.

In essence, the only changes to the original circuit are to increase the 100Ω resistor in series with diode D1 to 1kΩ 1W and increase the rating of the 10µF 25V supply filter capacitor to 35V. The MTP3055 Mosfet (Q3) is rated at 60V and will therefore run happily at the increased supply voltage.

No heatsink should be necessary for Q3 since LED strings do not draw much current. Fuse F1 could be reduced to 1-2A.

The design is still available as a kit from Altronics, Cat. K6008.

SILICON CHIP.

are followed by the data lines which are blue for a 1-bit and black for a 0-bit. The decoded data is output as serial data from output pins 2 & 3 which are data and clock respectively. These could be sent to another microcontroller, a UHF serial link or something similar.

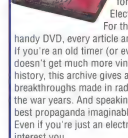
The whole circuit is powered from a 5V DC supply which could be from a USB port or perhaps a plugpack.

Note that this circuit shows the VGA lines being terminated with 75Ω resistors which is appropriate if the VGA port is only being used to decode the data, ie, there is a separate display used for viewing (such as the laptop's internal LCD screen). If you want to use the same VGA port to connect to a monitor and also for serial data, you would not terminate the lines (ie, omit the 75Ω resistors) as this is already done in the monitor.

The software for the PIC as well as Visual BASIC software to generate the display can be downloaded from the SILICON CHIP website. Advanced readers who want to try building this circuit could also consider modifying the software to allow IC1's two unused input pins to sense the state of the red and green VGA lines, allowing the same amount of data to be encoded in fewer lines on the display.

David Ward
Kapiti, NZ. ($60)

Radio, Television & Hobbies: the COMPLETE archive on DVD



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CLASSIC DAC MAIN PCB	APR 2013	01102131	$40.00
CLASSIC DAC FRONT & REAR PANEL PCBs	APR 2013	01102132/3	$30.00
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PIC16LF88-I/P	Garbage Reminder (Jan13)
PIC16LF88-I/SO	LED Ladybird (Apr13)
PIC16F877A-A/P	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10) Sentest (Feb-May12)
PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F45K80	USB Power Monitor (Dec12)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
PIC18F14K50	USB MIDIMate (Oct11)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)
PIC18LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC18F1320-I/SO	Intelligent Dimmer (Apr09)
PIC32MX795F512H-80I/PT	Maximite (Mar11), miniMaximite (Nov11), Colour Maximite (Sept/Oct12)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11), Level (Sep11) Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicolor (Nov12)
dsPIC33FJ128GP306-I/PT	CLASSIC DAC (Feb-April 13)
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04/13

CLASSiC DAC Pt.3

Third article has the full PCB layout & the assembly details

Last month, we described all the features of the CLASSiC DAC and how it works in some detail. Now it's time to put it together and get it going. There are quite a few parts to install, so let's start building it.

THE CLASSiC DAC is built on two PCBs: a main PCB coded 01102131 (157 x 198mm) and a front-panel PCB coded 01102132 (219 x 35mm). A third PCB coded 01102133 (219 x 35mm) is used for the rear panel and the entire assembly is housed in a standard low-profile instrument case measuring 225 x 165 x 40mm.

Fig.11 shows the parts layout on the main PCB. This holds most of the parts, including all the SMDs which must be installed first. Alternatively, if a kit is made available, the PCB will probably be supplied with the SMDs pre-loaded. So if you are building one of these kits, you can skip the following section and move straight on to fitting the through-hole components.

There are five fine-pitch SMDs to install but if you are careful and follow our instructions, you should be able to reliably hand-solder them. Start with ICs1-3 and IC7, all of which are in similar Shrink Small Outline Packages (SSOP), although IC7 has 20 pins while the rest have 28.

First, remove one of the chips from its protective packaging and place it alongside the appropriate set of pads with the marked side up. Check the part code with a magnifying glass to ensure it's going in the right place and find the small divot or dot in the corner which indicates pin 1. Once you have located it, gently rotate the part so that this dot lines up with the pin 1 indicator on the PCB layout.

We've described SMD soldering techniques on a number of occasions in the past so we'll just cover the basics here (for more information, refer to pages 80 & 81 in the June 2012 issue of SILICON CHIP). You will need a soldering iron with a reasonably fine tip (medium conical or chisel is fine), good quality solder of 0.7mm diameter or less, solder wick, flux paste, tweezers, a desk lamp or other strong source of light, a magnifier of some sort and ideally, a syringe of flux paste ("no-clean" type if possible).

Start by carefully applying a tiny bit of solder to one of the IC pads. If you are right-handed it's generally best to start with the upper-right pad or if you are left-handed, the upper-left. Then,

using tweezers, slide the chip into place while heating the solder on that pad. That done, remove the iron and check that the part is correctly orientated and that it is centred on its pads.

All pins must be over their corresponding pads and not too close to an adjacent pad. In particular, check that the IC is not rotated too much, ie, the pins should all be parallel to their pads (you will require a magnifying glass to check this properly). If the position isn't good enough (it rarely is on the first attempt), reheat the soldered pin and gently nudge the chip into place. Once it's correctly aligned, solder the diagonally opposite pin.

It's a good idea to now recheck the orientation of the IC and, if necessary, reheat that second pin since it's easy to rotate the chip slightly during the soldering process. You can then solder the rest of the pins, starting at one of the other corners. Don't be concerned if you bridge some of the pins during this process, as that can be easily fixed up later.

Once all the pins have been soldered, refresh the solder on the first couple of pins you soldered.

Now use solder wick to clean up any bridges. A dab of no-clean flux paste applied to the bridge beforehand makes this a lot faster and easier. In fact, we recommend applying flux paste along both edges of the IC and then cleaning the pins up with solder wick even if there are no apparent bridges as this reduces the chance of bad joints.

When finished, carefully examine the chip under magnification to ensure that no bridges are left (also check the top of the pins, where they enter the IC package). It's also a good idea to examine the area where the pins are in contact with the PCB pads to ensure that the solder has flowed onto the pads properly.

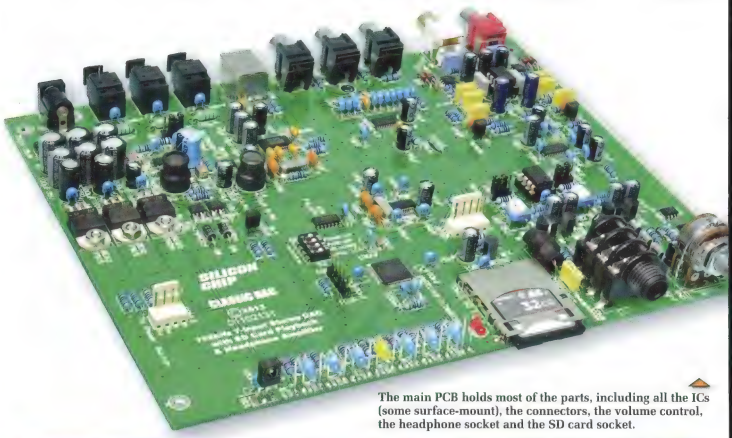
Repeat this procedure for the other three SSOP ICs. Once they are all in place, the remaining flux paste can be removed from the PCB and the ICs using isopropyl alcohol and a lint-free cloth. However, this isn't strictly necessary if you used no-clean flux paste.

Remaining SMDs

The only remaining fine-pitch chip is microcontroller IC5. This has a similar pin pitch to the aforementioned ICs (slightly smaller, in fact) and it also has pins on all four sides. The soldering technique described above works just as well for this device but you will need to be extra-careful to check the alignment of the pins on all four sides before you solder the second pin.

Note that the pin 1 dot is in one corner and a corresponding dot is shown on the PCB, just outside the quad flat-pack outline.

The next job is to solder the small outline integrated circuit (SOIC) parts. These include IC8 (14 pins), REG4



The main PCB holds most of the parts, including all the ICs (some surface-mount), the connectors, the volume control, the headphone socket and the SD card socket.

Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	4	1MΩ	brown black green brown	brown black black yellow brown
❑	18	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	6	22kΩ	red red orange brown	red red black red brown
❑	8	10kΩ	brown black orange brown	brown black black red brown
❑	7	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	3	3kΩ	orange black red brown	orange black black brown brown
❑	6	1.5kΩ	brown green red brown	brown green black brown brown
❑	1	1.2kΩ	brown red red brown	brown red black brown brown
❑	6	1kΩ	brown black red brown	brown black black brown brown
❑	2	750Ω	violet green brown brown	violet green black black brown
❑	7	470Ω	yellow violet brown brown	yellow violet black black brown
❑	2	240Ω	red yellow brown brown	red yellow black black brown
❑	1	180Ω	brown grey brown brown	brown grey black black brown
❑	7	100Ω	brown black brown brown	brown black black black brown
❑	3	75Ω	violet green black brown	violet green black gold brown
❑	6	22Ω	red red black brown	red red black gold brown
❑	2	10Ω	brown black black brown	brown black black gold brown
❑	1	2.2Ω (5%)	red red gold gold	not applicable

(8 pins) and the six dual Mosfets (8 pins). These are much easier to install than the previous ICs, as their pins are further apart.

However, while their pins are spaced widely enough to be soldered individually, it's easier and more reliable to use the same technique described above; ie, apply a generous amount of solder to all the pins, then clean up the joints using solder wick and flux paste to remove any solder bridges.

REG5 goes in next and it has an even wider pin spacing so you should be able to solder its pins individually without bridges. That done, install the five SMD ceramic capacitors but be careful to let the first joint solidify before you try to make the second, otherwise surface tension can pull the part out of place.

The last SMD part to fit is the SD card socket which may or may not

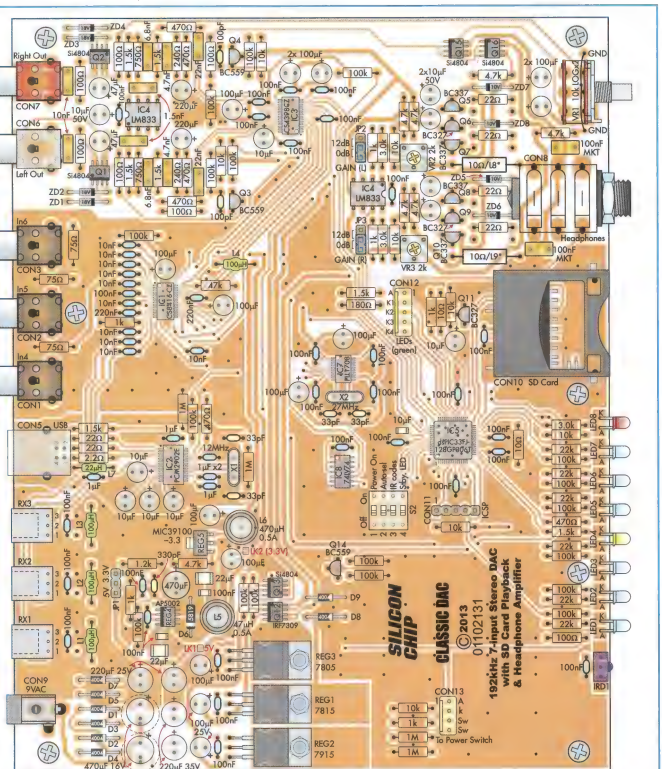


Fig.11: the parts layout for the main PCB of the CLASSiC DAC. Nearly all the parts are mounted on this PCB and all parts are installed on the top side of the board. The DAC IC circuitry is at upper-left, with the headphone amplifier at upper-right. The digital audio receiver is below the DAC and then further down is the USB audio chip (IC2) and below that, in the bottom-left corner, the power supply. The control circuitry, including microcontroller IC5, is at mid to lower-right.

come pre-soldered in a kit. This has two small plastic posts which fit into holes on the PCB. Remove the internal plastic frame which protects it during transport. You should find that it won't move much once the posts go in the holes and it's then just a matter of carefully soldering the SMD pins one at a time, starting with the two large ones on either side near the edge of the PCB.

It's probably a good idea to check its orientation after soldering the first pin to make sure it's properly aligned with the edge of the PCB. There are 11 pads to solder on the inside of the

CLASSiC DAC Parts List

1 main PCB, code 01102131, 157 x 198mm
1 front panel PCB, code 01102132, 219 x 35mm
1 rear panel PCB, code 01102133, 219 x 35mm
1 low-profile instrument case, 225 x 165 x 40mm (Altronics H0474, Jaycar HB5972)
4 100µH axial RF chokes (L1-L4)
1 47µH 500mA+ bobbin inductor (L5)
1 470µH 100mA+ bobbin inductor (L6)
1 22µH axial RF choke (L7)
1 10kΩ dual-gang 16mm log potentiometer with D-shaft (VR1)
1 knob to suit VR1 (eg, Altronics H6211)
2 2kΩ mini horizontal sealed trimpots (VR2,VR3)
1 12MHz HC-49 crystal (X1)
1 27MHz HC-49 crystal (X2)
1 4-way DIP switch (S2)
3 3-way pin headers with shorting blocks (JP1-JP3)
3 16Mbps TOSLINK receivers (RX1-RX3)
3 black switched PCB-mount right-angle RCA sockets (CON1-CON3)
1 PCB-mount right-angle type B USB socket (CON5)
1 white switched PCB-mount right-angle RCA socket (CON6)
1 red switched PCB-mount right-angle RCA socket (CON7)
1 PCB-mount 6.35mm jack socket with long pins (CON8)
1 PCB-mount DC socket (CON9)
1 Oupiin PCB-mount SD card socket (CON10) [Altronics P5720]
1 5-way pin header, 2.54mm pitch (CON11)
1 5-way polarised pin header, 2.54mm pitch (CON12)
1 4-way polarised pin header, 2.54mm pitch (CON13)
1 5-way right-angle polarised pin header, 2.54mm pitch (CON14)
1 4-way right-angle polarised pin header, 2.54mm pitch (CON15)
2 5-way polarised plugs with crimp pins
2 4-way polarised plugs with crimp pins
1 200mm length 10-way ribbon/rainbow cable
1 infrared receiver (IRD1) [Jaycar ZD1952, Altronics Z1611A]
1 panel-mount momentary push-button switch with integral LED (S1) (Altronics S0933)
2 8-pin DIL sockets
1 2m length 0.4mm diameter enamelled copper wire
1 40mm length 10mm diameter heatshrink tubing
1 60mm length 0.7mm diameter tinned copper wire
3 M3 x 6mm machine screws with nuts and shakeproof washers
6 No.4 x 6mm self-tapping screws or M3 x 6mm machine screws
1 9VAC 0.67A plugpack (Altronics M9231)
1 universal infrared remote control (optional; Altronics A1012 suggested)
1 high capacity SD/SDHC/SDXC card (optional)

Semiconductors

1 CS8416-CZZ digital audio receiver [TSSOP-28] (IC1) [element14 1023452, Digi-Key 598-1124-5-ND)
1 PCM2902E USB audio IC [SSOP-28] (IC2) [element14 8434700, Digi-Key 296-12986-5-ND)
1 CS4398CZZ 24-bit 192kHz DAC [TSSOP-28] (IC3) [element14 1023397, Digi-Key 598-1067-5-ND)
2 LM833N/LM833D dual op amps (IC4,IC6)
1 dsPIC33FJ128GP306-I/PT microcontroller programmed with 0110213A.hex [TQFP-64 package] (IC5) [element14 1294837, Digi-Key*]
1 PLL1708DBQ clock generator [SSOP-20] (IC7) [Digi-Key 296-14183-5-ND]
1 74LV74D dual flip-flop IC [SOIC-14] (IC8) [element14 1085356, Digi-Key 568-7663-1-ND]
1 7815 15V 1A linear regulator (REG1)
1 7915 -15V 1A linear regulator (REG2)
1 7805 5V 1A linear regulator (REG3)

socket plus the two aforementioned mounting pins on either side and two at the rear.

Now make a final inspection of all the SMD joints since it's going to be harder (although by no means impossible) to fix any solder bridges or bad joints later when the adjacent through-hole parts have been fitted.

Through-hole parts

Now fit all the 0.25W resistors. It's a good idea to check their values with a DMM beforehand since it can often be hard to distinguish certain colours. There are about 90 resistors, so it will take some time to install them.

The diodes are next on the list. Make sure that you don't get the four different types mixed up and check that they are orientated as shown on the layout diagram. Virtually all of the diodes go in with their cathode stripe towards the front of the PCB (ie, right side on the diagram) **but two of the 10V zeners are installed the other way around, so be careful with those.**

Now fit the five axial inductors, noting that L7 has a different value from the other four. Follow with the two 8-pin DIL sockets for IC4 and IC6 (orientate the notches as shown), then solder crystals X1 (12MHz) and X2 (27MHz) in place (don't get them mixed up).

Follow with the three TO-220 regulators. In each case, bend the pins down through 90° 6mm from the body and then attach the tab to the PCB using an M3 x 6mm machine screw, shakeproof washer and nut. Do the nut up tightly and then solder and trim the three pins. Note that each regulator is a different type.

You can now fit the small signal transistors, bending their leads with small pliers to fit the pads. There are three different types, so match them to the type numbers shown on the PCB and parts list.

The 4-way DIP switch can now be fitted, with its "ON" marking matching that on the board. Once it's in, install VR2 & VR3, followed by the MMC, ceramic disc and MKT capacitors.

Large inductors

You now need to wind the two output inductors (L8 & L9, near headphone socket CON8) onto the 10Ω 1W

1 AP5002S switchmode regulator [SOIC-8] (REG4) [element14 1085356, Digi-Key*]
1 MIC39100-3.3WS or LM3940IMP-3.3 LDO regulator [SOT-223] (REG5) [element14 1556715/9779280, Digi-Key 576-1172-ND*]
5 Si4804CDY dual N-channel Mosfets [SOIC-8] (Q1,Q2,Q13, Q15,Q16) [element14 1779273, Digi-Key*]
3 BC559 PNP transistors (Q3,Q4, Q14)
4 BC337 NPN transistors (Q5,Q7, Q8,Q10)
3 BC327 PNP transistors (Q6,Q9, Q11)
1 IRF7309 dual N+P channel Mosfet [SOIC-8] (Q12) [element14 9102175, Digi-Key*]
8 1N4004 1A diodes (D1-D5, D7-D9)
1 1N5819 1A Schottky diode (D6)
4 18V 1W zener diodes (ZD1-ZD4)
4 10V 1W zener diodes (ZD5-ZD8)
6 blue 3mm LEDs with diffused lenses (LED1-3,LED5-7) [Seeed Studios]
1 yellow 3mm LED with diffused lens (LED4)
1 red 3mm LED with diffused lens (LED8)
4 green 3mm LEDs with diffused lenses (LED9-LED12)

Capacitors

3 470µF 16V electrolytic
2 220µF 35V electrolytic
2 220µF 25V electrolytic
14 100µF 16V electrolytic
2 47µF 16V electrolytic
2 22µF 25V SMD ceramic, size 4832/1812
11 10µF 50V electrolytic
1 10µF 6.3V SMD ceramic, size 3216/1206
5 1µF MMC
2 220nF MMC
2 100nF 50V X7R SMD ceramic, size 3216/1206
29 100nF MMC
2 100nF MKT
2 22nF MKT
10 10nF MMC
2 10nF MKT
2 6.8nF MKT
2 4.7nF MKT
2 1.5nF MKT
1 330pF ceramic disc
2 100pF ceramic disc
4 33pF ceramic disc

Resistors (0.25W, 1%)

4 1MΩ	2 750Ω
18 100kΩ	7 470Ω
1 47kΩ	2 240Ω
6 22kΩ	1 180Ω
8 10kΩ	7 100Ω
7 4.7kΩ	3 75Ω
3 3kΩ	6 22Ω
6 1.5kΩ	2 10Ω
1 1.2kΩ	2 10Ω 1W 5%
6 1kΩ	1 2.2Ω 5%

** Note: catalog number for Digi-Key components listed are the same as the part type code*

Capacitor Codes

Value	µF Value	IEC Code	EIA Code
220nF	0.22µF	220n	224
100nF	0.1µF	100n	104
22nF	0.022µF	22n	223
10nF	0.01µF	10n	103
6.8nF	.0068µF	6n8	682
4.7nF	.0047µF	4n7	472
1.5nF	.0015µF	1n5	152
330pF	NA	330p	331
100pF	NA	100p	101
33pF	NA	33p	33

Component Change

Since publishing the circuit last month, we have decided to change the value of RF inductor L7 from 100µH to 22µH (bottom of Fig.4, p21, March 2013). That's because the resulting lower DC resistance of the inductor improves the unit's immunity to severe power supply noise which may be coupled in via the host PC's power supply (whether it is a desktop or laptop).

This change is reflected in the parts list and PCB overlay published this month.

resistors. To do this, cut a 1-metre length of 0.4mm-diameter enamelled copper wire and strip 3-4mm of the insulation from both ends using a sharp hobby knife or fine emery paper. That done, tin both ends, then solder one end to the lead of a 10Ω resistor, as close to the body as possible.

It's then just a matter of carefully winding the wire around the resistor body; they normally narrow in the middle which helps keep the windings in place. Wind the turns as close together and as neatly as possible. Once you have wound on as many turns as you can fit, start a new layer in the opposite direction and repeat until you've used up all the wire.

The first couple of layers can be pretty neat but you will probably find that the last couple are a bit messy. This doesn't matter; just keep the turns tight and make it as neat as you can. Once the winding is finished, solder the free end to the other lead of the resistor, again adjacent to the body.

Finally, slip a 15mm length of 10mm-diameter heatshrink tubing over the inductor and shrink it down using a hot-air gun to hold the windings firmly in place.

It should now be possible to bend the resistor's leads down close to its body and solder the part in place. This process is then repeated for the other resistor/inductor. The orientation isn't critical, although it's preferable to install them with their windings going in the same direction.

The two pre-wound bobbin inductors (L5 & L6) can also now be fitted. Note that while these may look identical, they have different values. If they aren't marked and you don't know which is which, the lower value inductor should have a substantially lower DC resistance as measured with a standard DMM.

Install the four pin headers next, followed by the USB socket (CON5), the electrolytic capacitors, the DC power socket (CON9) and the TOSLINK receivers (RX1-RX3). The RCA sockets can then go in but make sure these sit flat against the PCB and are perpendicular to the adjacent edge before soldering their pins.

In fact, it's best to solder one pin of each RCA socket first, then carefully adjust each socket before soldering its remaining pins. Use black sockets for CON1, CON2 & CON3 (the S/PDIF inputs), a white socket for CON6 and a red socket for CON7.

Finishing up

The next step is to test fit headphone

Designing The CLASSIC DAC's PCB

WE DON'T normally go into much detail describing the PCB layout, other than to present the overlay diagram. But since this is one of the more complex and demanding PCBs we have designed, we thought it was worth going over it quickly to explain the salient points of the design.

We decided from the outset to place the power supply on the opposite side of the PCB to the analog circuitry to minimise the chance of rectifier buzz or other power supply noise from getting into the analog paths. As a result, the power supply is located at the left rear of the PCB, while the analog outputs are at right rear, with the digital audio circuitry in between.

It was then immediately clear that with the power input socket at the left side of the rear panel and the analog outputs at right, the seven digital input sockets had to be spaced out between them. The logical place for the headphone socket and volume control was then on the right side of the front panel, to minimise the distance that the analog signal had to travel from the DAC chip to the headphone amplifier.

It's preferable to have the power switch at one end of the front panel so this then had to go on the left, with the status LEDs and SD card socket in the middle.

With all the main component locations determined, that just left the routing of the tracks. In doing this, we used three overriding principles to guarantee good performance: (1) join the digital and analog grounds at one point only (ideally, in the power supply); (2) minimise any radiation from the digital tracks; and (3) if possible, use a star earth for the analog ground tracks.

We ended up joining the two sets of ground tracks at two different points. However, they are both close together, near the TO-220 regulators, and due to the thickness of the ground planes and numerous vias joining the top and bottom layers, there is no measurable digital noise coupling into the analog grounds.

EMI from the digital circuitry was minimised by filling all the spare areas around and under digital tracks with copper ground planes. These are studded with dozens of vias between the top and bottom ground planes, thereby minimising the impedance through which ground currents flow. By doing this, the loops through which digital currents flow are kept very small and so very little magnetic radiation is produced which could otherwise couple into nearby analog tracks.

In addition, all the SMD ICs have a ground fill underneath them on both layers. For the critical ICs, such as the digital audio receiver, DAC, USB-to-S/PDIF converter and clock generator, a zig-zag of vias is placed directly under the chip to provide even better earthing. This does the same job for the internals of the IC as the copper fill does for external tracks, ie, it minimises electromagnetic coupling into, out of and between the parts inside the chips.

Ground planes are also used under some parts in the analog section but these have been carefully designed so that they provide a star earth. The left and right channels have separate ground fills between the line output sockets and they join near the copper fill under the DAC IC. The DAC's ground is then connected straight to the ground pin of the headphone socket, where the headphone amplifier and volume control grounds are also joined.

A single track then runs from this point back down the middle of the board (along with the other power supply tracks which must run its length) and then down to where the digital and analog earths are joined.

To further reduce the chance of any switched loads generating EMI which could affect the analog section, the LED brightness is not controlled by PWM (except in standby mode when the DAC is off). Instead, multiple microcontroller outputs and current-limiting resistors are used to control the currents through the LEDs.

socket CON8 and potentiometer VR1 on the PCB. Push these parts down as far as they will go, then check that the headphone socket's entry hole lines up with VR1's shaft. Provided you've used the socket specified in the parts list, it should be correct.

On the other hand, if the socket is too low, you will need to swap it for a slightly different type which has wide pins emerging from the bottom of the plastic housing which then narrow to go into the PCB holes.

Assuming you do have the right socket, install it now, making sure that it sits flush against the PCB.

Before soldering VR1 into place, first check the distance between its threaded screw section and the D-shaped profile of the shaft. If it's like the one we used and there is only a 2mm cylindrical shaft section, then you can leave it as it is. However, if the flat section stops much further from the screw thread, you will need to file the rear section of the shaft flat. This can be done by holding the shaft in a vice and then using the flat section as a guide to file the rest down.

Now cut the shaft at exactly 10mm from the screw thread using a hacksaw and clean up the edges with a file. That done, file a small area of passivation off the very top of the pot body. Do not breathe the dust during this process (wear a face mask) and be sure to wash your hands after cleaning up, as it may be plated with cadmium which is a heavy metal.

The pot can now be soldered to the PCB. Once it's in, solder a length of tinned copper wire to the adjacent pad marked "GND", then bend it over the top of the pot (ie, over the section you filed clean) and solder it to the pad marked "GND" on the other side. Finally, solder this wire to the top of the pot as well, so that the metal body is grounded.

Preparing the case

It's easier to install the remaining components with the board in the case but first, some of the plastic posts must be removed from the base. Begin by checking which way around the board goes – it only fits one way since the posts are not symmetrically arranged – then remove any posts which don't correspond to a mounting hole on the PCB (ignore the four right next to the taller posts).

You can remove the unwanted posts by filing them down or cutting/levering them off with side-cutters and pliers. There are two at the front to get rid of (ie, under the SD card socket and headphone socket) and three at the rear (the middle three along the edge).

Now remove any nuts and washers from the pot and headphone socket and slip the front panel over their shafts. That done, lower the assembly into the case, guiding the front panel into its slots. Check that the main board sits flat on its mounting posts on the base, then secure the board in place by fitting self-tapping screws to the four mounting holes behind the front panel.

Note: M3 x 6mm machine screws can also be used here, although you will have to use some force to cut a thread in the plastic posts the first time you install them.

Fitting the LEDs

You can now fit the eight LEDs along the front of the main PCB. The first step is to bend their leads down through 90° about 1mm back from the lens. Do this so that the longer (anode) lead will go through the hole marked "A" on the layout diagram. Check each LED carefully, then trim both leads on each device to about 14mm.

LED1 can now be fitted to its PCB pads and its lens slipped into its corresponding hole in the front panel. Make sure the lens is pushed all the way into its hole, then tack solder the leads to the pads on the top of the PCB. Repeat this process for the other seven LEDs, making sure that you use a yellow LED for LED4 and a red LED for LED8 (the others are all blue LEDs).

Now do the same for the infrared receiver (IRD1), except that its leads should first be trimmed to protrude around 8mm below its plastic body.

Once these parts are in, undo the mounting screws along the front edge of the main PCB, remove the assembly from the case and separate the two boards. You can now finish soldering the LEDs and IR receiver to the bottom of the PCB and trim any excess lead lengths.

Front panel assembly

That completes the main PCB assembly; now for the front panel board.

Fig.12 shows the parts layout on this PCB. Starting by fitting the two right-angle polarised pin headers. These are surface-mounted so install them in a similar way to the SMDs; ie, place a generous amount of solder on one of the pads, heat this solder and then slide the header into place. Make sure it's the right way around and sitting flat before soldering the remaining pins.

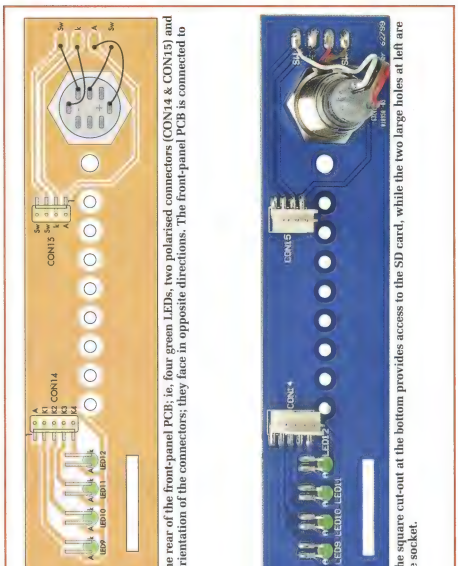


Fig.12: follow this diagram to mount the parts on the rear of the front-panel PCB; ie, four green LEDs, two polarised connectors (CON14 & CON15) and the illuminated power switch. Take care with the orientation of the connectors; they face in opposite directions. The front-panel PCB is connected to the main PCB via two cables.

This view shows the completed front-panel PCB. The square cut-out at the bottom provides access to the SD card, while the two large holes at left are for the volume control pot shaft and the headphone socket.

The four green LEDs are also surface-mounted but first their leads must be bent to suit. Start by bending them through an angle of about 100° right up against the rear of the lens, so that the longer (anode) lead is on the left as shown in Fig.12. That done, bend the leads back parallel to the rear of

This view shows the completed assembly from the rear with the top cover removed. The two audio output sockets are at left, then the three S/PDIF (coaxial) inputs, the USB audio input and the three TOSLINK (optical) inputs. The power socket (to connect a 9VAC plugpack) is at far right.

the lens so that with the LED pushed through its hole in the front panel, the leads sit flush against the surface of the PCB.

Finally, trim the LED leads to 6mm and solder each one to its pads. Be sure to push the rear of each lens firmly against the panel while soldering (eg, use a small screwdriver), so that each lens protrudes fully from its front-panel hole.

That just leaves the power switch. Mount it in position and tighten its nut so that the sides are roughly vertical, as shown in Fig.12. This is necessary so that when it is installed in the case, the IR receiver can fit next to it.

It's now just a matter of running four wires from the switch tabs to the their corresponding PCB pads. You can use ribbon cable or light-duty hook-up wire for this job. Note carefully the orientation of the "+" and "–" symbols at the rear of the switch.

Making the two cables

Fig.13 shows how to make the two cables that connect the PCBs together. These are made up using 4-way and 5-way lengths of ribbon cable.

Note that while you should ideally crimp both the insulation and the bare wire as shown, you can get away with just soldering the wires here, as there will be little stress on the cables. It's much easier than crimping but you will still need to at least partially crimp the insulation with small pliers so that the pins fit into the plastic blocks.

It's a good idea to hold the pins in an alligator clip stand while you solder them. Make sure they are held rigidly so that they don't move during soldering.

Once you've attached the pins to the cable, use a small jeweller's screwdriver to push them into the plastic blocks until they click into place. If you have to get one out again, use the same screwdriver to push in the small protruding tab through the hole in the plastic block while pulling it out.

Fig.13: here's how to make the two short connecting cables. It's a good idea to flow a little solder into the crimp joint which holds the bare copper strands to ensure they can't be pulled out, even if the crimps fail. Check that the pins are flat and straight after soldering, then push them into the moulded plastic blocks using a small screwdriver until they click in place.

Final assembly

Now for the final assembly. This first involves fitting the front and rear panels to the PCB, slipping the entire assembly into the case and installing the seven mounting screws. The assembly is then completed by plugging in the two cables, attaching the four rubber feet (supplied) to the bottom of the case, installing the washer and nut on the pot and finally, fitting the knob.

More to come

That's all we have space for this month. Next month, we will go through the procedure for testing and setting up the CLASSiC DAC. We will also go over some of the more interesting and important points of the software (firmware) design.

Finally, we will give details on how to use the unit, including the remote control set-up and the advanced configuration set-up. SC

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Ethernet Over Mains Power

Share Internet throughout your home using your power line. Plug this PLC adaptor into your AC power socket and connect it your modem by a Cat5 cable.

- Works up to 300m
- Energy efficient
- Power supply: 100 - 240VAC, 50/60Hz
- Size: 67.5(L) x 56(W) x 31(H)mm

YN-8352

NEW $99.00

10" Portable PA System with 7-Channel Mixer

Includes 2 x 100WRMS speakers, 7-channel mixer and microphone. Features built-in DSP effects, peak indicator and a variety of controls to fine-tune the audio frequency range. It can also play MP3s from an SD card or a USB flash drive. Easy to transport.

- Supports balanced or unbalanced mic or music instrument
- Mains powered
- Size: 320(L) x 320(W) x 475(H)mm

CS-2549

$499.00

Power Inverter with 2.1A USB Output

This can-sized inverter features a USB port with 2.1A output, allowing you to quickly charge many modern electronic gadgets from your car's cigarette lighter socket.

FITS IN CUP HOLDER

- 150W modified sine wave
- USB Output: 5VDC 2.1A
- Size: 165(L) x 60(Dia.)mm

MI-5127

NEW $44.95

HDMI Audio Extractor

No need to throw out your old audio system. Use this device to extract the audio signal from your HDMI source and redirect it for use via an SPDIF TOSLINK optical cable, SPDIF RCA cable or a 3.5mm to 2 x RCA cable for output to an amplifier or home theatre audio system.

- Size: 70(L) x 60(W) x 20(H)mm

AC-1637

NEW $99.00

Watch Pay TV All Over The House

Uses cutting-edge design in wireless DIGITAL 2.4GHz technology to send stereo audio and video interference free around the home. Also integrates an infrared extender which allows control of the settings from the receivers end. Supplied with power adaptors.

- Works with modern Pay/TV remotes
- Transmits up to 100m
- Size: 170(W) x 130(D)x 43(H)mm

AR-1872 *was $169.00*

$139.00 SAVE $30

2.4GHz DIGITAL Wireless Reversing Camera Kit

Comes with a 3.5" colour LCD which produces crystal clear video and can be mounted to a windscreen with the supplied suction mount bracket. The unit will accept up to 4 cameras for greater visibility of your surrounds.

NEW $249.00

- 12/24VDC
- Hassle free installation
- Transmission distance: 100m line of sight
- 420 TVLines camera resolution

QM-3802

Extra camera available separately (DUE MID APRIL) **QM-3803** $149.00

CARAVAN & MARINE

Electronic Antifouling Units for Boats

Helps keep the hull of your boat clean and free of most marine growth. Completely manufactured units are straight forward to install. Power is supplied by 12VDC and a low voltage cut-out feature is also included, which protects the boat's batteries from being over discharged. Each unit includes a control box (5m lead) and transducers (10m lead each), and a comprehensive installation & instruction manual. More details can be found on our website.

Dual Output suitable for vessels up to 14m (45ft)
YS-5600 ***was $899.00***
$799.00 SAVE $100

Quad Output suitable for vessels up to 20m (65ft)
YS-5602 ***was $1199.00***
$999.00 SAVE $200

NOTE: Larger vessels can simply use multiple units. Twin hull vessels will require double the recommendations above.

Marine Radio Transceiver

Powerful 5W hand-held transceiver covers all international VHF marine channels. Features a detachable antenna so it can be connected to a larger antenna mounted on a boat.

$119.00

- 1W/5W switchable output power
- Splash proof housing
- LCD backlit display
- One-touch emergency channel 16
- Main body size: 130(L) x 60(W) x 35(D)mm

DC-1096

Rust Resistant Speaker Systems

At last, speakers for your boat that will never rust. No metal grills, all plastic. Will work in any outdoor environment, however best to keep out of direct weather.

- Sold as a pair
- 2-way speaker, IP55
- Completely moulded in high density UV resistant plastic.

5" IP55 30WRMS
- Size: 215(W) x 155(H) x 115(D)mm

CS-2479 ***was $149.00***
$129.00 SAVE $20

6.5" IP55 40WRMS
- Size: 265(W) x 195(L) x 145(D)mm

CS-2480 ***was $179.00***
$149.00 SAVE $30

Silicone Rescue Tape

Designed for quick plumbing repairs, sealing hoses in your car/truck/boat, coating the ends of rope, wrapping tool handles, emergency o-ring seals or to insulate electrical wiring. Tightly wrap the tape for a quicker bond.

- Size: 25mm x 3600mm

NA-2829
$19.95 roll

CREE® LED Glass Globes

Replacement CREE® LED glass globes for your car, caravan, or boat.

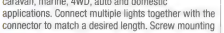
- 12VDC

BA15D CREE® LED
ZD-0513 $19.95
BA15D 3 x CREE® LED
ZD-0515 $29.95

NEW
FROM $19.95

Linkable LED Strip Light

A stylish aluminium LED strip light suitable for caravan, marine, 4WD, auto and domestic applications. Connect multiple lights together with the connector to match a desired length. Screw mounting holes included.



- 280 Lumens
- Input voltage: 9 - 30VDC, 3W
- 3528 SMD LEDs (42 Pieces)
- Size: 300(L) x 20(W) x 9(H)mm

ST-3918
$29.95

24 LED Caravan Roof Light

For a reliable light source in your caravan, this 12VDC powered light uses an array of 24 high brightness white LEDs that will light up your interior.

- 400 lumens
- 12VDC, 9W
- Size: 213(L) x 66(W) x 41.5(H)mm

SL-3447 ***was $44.95***
$34.95 SAVE $10

Satellite Finder with LED Display

Align a satellite dish quickly and accurately with this handheld satellite finder. Perfect for setting up permanent dishes as well as portable systems on caravans or RVs.

- Size: 90(L) x 48(W) x 31(H)mm

LS-3302
$24.95

Set-up your Caravan with Great TV Reception

Outdoor UHF/VHF/Marine TV Antenna

Digital ready outdoor antenna perfect for caravans. Use the included remote control to rotate the antenna for the best signal. Receives UHF & VHF signals.

- Includes booster amp
- 8m TV cable and mains adaptor included
- Remote requires 2 x AAA batteries
- Size: 750mm wide when deployed

LT-3143
$59.95

12VDC HD Digital Set Top Box

Receives SD and HD digital channels on offer in your locale. Insert a USB flash drive to record programmes to playback later. Remote and cigarette lighter power cable included.

- 12/24VDC
- Size:154(W) x 117(D) x 40(H)mm

XC-4921
$69.95

NOTE: Not available in New Zealand

Solar Powered Ventilator

Completely solar powered to reduce mould, mildew, moisture and excess heat build-up in boats, caravans and RVs, or anywhere else you need air extraction. Cut-out size: 150mm.

- Wall or roof mounting
- Stainless shroud
- Size: 215(Dia.) x 30(H)mm

MP-4559 ***was $79.95***
$59.95 SAVE $20

Solid LED Lights for 4WD or Marine Use

Extremely high light output (up to 4340 lumens), near unbreakable, shockproof and completely waterproof, these solid LED lights are a much better alternative to traditional halogen spotlies.

NEW LOWER PRICE

- 50,000 hour life
- Aluminium alloy & stainless steel
- 9-32VDC input

FROM $99.00

2" 12W with 4 LEDs Spotlight (1430 Lumens)
SL-3911 $99.00
4" 24W with 8 LEDs Light Bar (1736 Lumens)
SL-3912 $149.00
10" 60W with 20 LEDs Light Bar (4340 Lumens)
SL-3914 $349.00

NOTE: 24V systems will need 12V relay replaced with 24V item

15A Extension Leads

Heavy duty mains extension leads with 15A plugs and sockets, and a thick orange flexible cord. Perfect for caravans and motorhomes.

10m PS-4182 $19.95
15m PS-4184 $29.95
20m PS-4186 $39.95

FROM $19.95

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/04/2013.

AUTO & OUTDOORS

Slim Ballast HID Kits for Cars

HID provides far greater light output than standard automotive lights. This series of kits all feature a slim ballast design for ease of installation in engine bays and tight spaces.

- 12V 6000K • Ballast size: 85(L) x 61(W) x 15(H)mm

H1 Slim Ballast HID Kit	SL-3490	$49.95
H3 Slim Ballast HID Kit	SL-3492	$49.95
H4 Slim Ballast HID Kit	SL-3494	$49.95
H4 Slim Ballast HID High/Low Kit	SL-3495	$79.95
H7 Slim Ballast HID Kit	SL-3496	$49.95

NEW FROM $49.95

Bike Head Torch

Providing up to 700 lumens of intense white light, this head torch is the ideal safety addition for any cyclist. Mains charger included.

- Includes handle bar bracket
- Modes: High, low, flashing
- Burn time: 20hrs on low brightness
- Size: 60(L) x 46(Dia.)mm

ST-3464

NEW $99.00

Keep Track of your Car, Truck or Boat

Locate and track the whereabouts of your vehicle in real time via the Internet on a computer or Smartphone. Insert a GSM Sim card (not included) and hide the device away. It works by sending the vehicle's GPS coordinates via the GSM network to the free online tracking service, which shows the location on Google Maps®. It can also SMS longitude and latitude coordinates to up to 3 mobile phones. See website for full features and specifications.

- 12-24VDC
- Size: 68(L) x 48(W) x 20(D)mm

LA-9011

$149.00

Car Battery Monitor

Check the voltage output of a car's battery quickly and easily. Simply plug this handy voltmeter into the cigarette lighter socket and get an instant readout.

- Display resolution: 0.1V
- Operating voltage: 8 - 30VDC

QP-2220

$19.95

Reversing Camera with 5" LCD Monitor - Wired

An easy to setup and affordable all-in-one reversing camera kit. Includes a slimline 5" LCD monitor, a powerful suction mount bracket, and a tiny reversing camera to be mounted at the rear of the vehicle.

- Camera cable length: 2m
- LCD size: 127(L) x 82(W) x 15(D)mm
- Bracket size: 133(H) x 65(Dia.)mm

QM-3741

$199.00

CREE® Rechargeable Torches

Tough, military grade torches featuring the CREE® XM-L LED for superior light efficiency and brightness. They are sealed to protect against water, dust, and dirt, perfect for the next adventure.

- Light modes: High, medium, low, flashing, SOS
- Includes 2 x rechargeable batteries & mains charger

750 Lumen CREE® XML

- Size: 230(L) x 55(Dia.)mm

ST-3482

NEW $59.95

2500 Lumen 3 x CREE® XML

- Size: 220(L) x 55(Dia.)mm

ST-3484

NEW $119.00

Outdoor Power Briefcase Solar Chargers

FROM $19.95

Great for keeping a car battery topped up while on holidays or in storage. Three sizes for small, medium and large cars or 4WDs. Each terminates in a cigarette lighter plug or alligator clips.

12V 2W Charger
- Size: 304(L) x 185(W) x 17(H)mm

ZM-9036 $19.95

12V 4W Charger
- Size: 445(L) x 237(W) x 17(H)mm

ZM-9037 $34.95

12V 7W Charger
- Size: 492(L) x 335(W) x 18(H)mm

ZM-9038 $59.95

Wireless Tyre Pressure Monitoring Kit

Unevenly or inadequately inflated tyres can cause steering alignment problems. This device fits 4 sensors to your tyre stems that feed PSI data to a 12VDC monitor inside the car helping you to know when you need to take action to inflate them back to a desired level.

- Suitable for vehicles designed for 30-42PSI
- Sensor size: 23.5(Dia.) x 15(H)mm

QP-2298

NEW $199.00

Car Cigarette Lighter Socket

Power and charge four of your gadgets while on the road. Mounting hardware included.

- 12VDC plug with 1.2m lead
- 4 x 12VDC socket outputs
- 1 x 5VDC 1A USB port
- 10A max

PS-2019

$19.95

LED Torch with Radio & Charger

An extremely handy rechargeable torch for your next camping trip. Features 3 bright white LEDs, an AM/FM radio, as well as a personal alarm in case of emergency.

- Includes 1 x USB MicroB, 1 x USB MiniB, 1 x Nokia plug adaptors
- Size: 136(L) x 48(W) x 34(H)mm

ST-3357

NEW $29.95

Windscreen Mounting "Black Box"

This 5" touch screen LCD fits onto a windscreen and features a built-in camera to record vision through the windscreen as you drive, MP3 player and FM radio to entertain, GPS navigation function*, movie player, photo viewer, e-book reader and much more. See website for features & specifications.

- 800 x 480 resolution
- Rechargeable for portable use
- Built-in GPS antenna
- Supports microSD upto 8GB and MMC cards
- Windows CE
- 3.5mm stereo audio output
- Size: 134(W) x 83(H) x 13(D)mm

QV-3812

NEW $169.00

*Note: Mapping software not included but can be purchased directly from GPS mapping solution companies online.

150W Inverter with USB Outlet

Plugs directly into your vehicle's cigarette lighter socket to deliver 230VAC at 150 watts. Comes with a USB port to charge or power USB operated device.

- Modified sine wave inverter
- 12VDC
- Size: 150(L)mm

MI-5125 ***was $44.95***

Limited stock. Not available online.

CRAZY CLEARANCE

$19.95 SAVE $25

Power up your Batteries

140A Dual Battery Isolator Kit

Allows two batteries to be charged from your engine alternator at the same time. The isolator automatically engages and disengages depending on the charge condition of the start battery. Supplied as a full kit.

- Isolator size: 67(L) x 67(W) x 53(H)mm

MB-3686

Dual Battery Isolator available as a standalone unit NEW MB-3685 $79.95

NEW $139.00

Multi Stage Battery Chargers

High tech SLA battery chargers for automotive, workshop or industrial use. All feature switchmode operation, multi-stage maintenance and charging plus microprocessor control. See website for individual model specifications.

MB-3603

MB-3606

- Short circuit and reverse polarity protection
- Anti-spark protection
- Dust & splash proof (IP rated)
- Safe to leave connected for months at a time

FROM $49.95

6/12V 3-Stage MB-3603 $49.95
12V 3.8A 5-Stage MB-3604 $79.95

Switchmode Power Supplies

These range of switchmode power supplies offers higher efficiency and reliability. Features overload protection and current limitation, screw down terminals and strong metal case.

GET 20% OFF ADVERTISED PRICE

- Built-in EMI filter MP-3104

MP-3109

MP-3118

25W 12V	MP-3102	$54.95
25W 24V	MP-3103	$54.95
40W 12V	MP-3104	$69.95
40W 24V	MP-3106	$69.95
60W 12V	MP-3107	$74.95
60W 24V	MP-3109	$74.95
60W 5V & 12V Dual Output	MP-3108	$79.95
100W 12V	MP-3121	$84.50
150W 12V	MP-3110	$109.00
150W 15V	MP-3112	$109.00
150W 24V	MP-3114	$109.00
240W 13.8V	MP-3118	$219.00

NOTE: These are not stand alone units. They have exposed 240V terminals. They are meant to mount inside secure, earthed cabinets.

FROM $54.95

Car Power Adaptors

Use your car's cigarette lighter socket to power or charge a variety of portable electronic devices.

12VDC 1.5A Car Adaptor
- Size: 99(L) x 41(W) x 31(D)mm

MP-3677 $19.95

NEW FROM $19.95

12VDC 3A Car Adaptor with USB Outlet
- Size: 80(L) x 76(W) x 33(D)mm

MP-3671 $29.95

MP-3677

Intelligent 5 Stage Battery Charger

Charge and maintain 12V batteries with this microprocessor controlled charger. Features reverse polarity protection, overheat protection, voltage compensation, fan cooling and more. 5 stage charging (soft start, bulk charging, absorption, float and pulse).

- Suits WET/Flooded, GEL, AGM, MF, VRLA, Calcium type lead acid rechargeable batteries
- Size: 230(H) x 170(W) x 140(D)mm

MB-3625

NEW $99.95

SLA Battery Boxes

Protect your batteries with these sturdy boxes . Perfect for mounting in your boat, trailer or caravan. Includes mounting clamps and lid strap to secure the box properly in place.

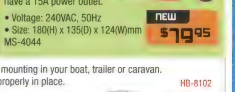
HB-8102

Suit 40Ah SLA batteries HB-8100

NEW $24.95

Suit 100Ah SLA batteries HB-8102

NEW $29.95



HB-8100

Lightning™ Plug Adaptors

A range of adaptors suitable for connecting the iPhone® 5 and other Apple® devices using the new Lightning™ connector to peripherals that use the 30-pin Apple® connector such as iPhone® docks, etc. We also have a model that converts the Lightning™ adaptor to Micro-B USB.

Lightning™ Plug to 30-Pin Apple® Socket Adaptor WC-7726 $14.95

Lightning™ Plug to 30-Pin Apple® Socket Adaptor Lead WC-7727 $14.95

Lightning™ Plug to 30-Pin Apple® Socket Lead WC-7729 $14.95

NOTE: All units are for charging and syncing only.

NEW $14.95 EA

USB Charge & Sync Lead to suit Lightning™ Socket

Connect Lightning™ connector devices such as the iPhone 5® or iPad mini® to any USB port for charging or data syncing.

- Cable length: 1m

WC-7728

NEW $14.95

Home Lighting

200W Mains Dimmer Switch

Suitable for Dimmable LED Bulbs or Incandescent lights.

- Push ON/OFF or rotate to adjust light level.
- Operating Voltage: 200-240VAC,1A
- Maximum Power: 200W
- Configuration: Leading Edge or Trailing Edge

PS-4084

NEW $24.95

Incandescent Replacement Globes

Drop-in replacement halogen globes that will fit standard bayonet or Edison screw fittings.

$2.45 Each

SL-2795

- Comes in pack of 2

42W Edison Screw SL-2795 $2.45
42W Bayonet SL-2796 $2.45

100W also available. See staff or check online

MPPT Solar Charge Controller

MPPT technology uses DC to DC conversion to extract the absolute maximum charging power from your solar panels. Features 3-stage battery charging, twin timer programming, 30A load control with automatic load disconnection/reconnection, and much more. Suitable for 12V or 24V systems.

- 360W (12V) or 720W (24V)
- Size: 205(L)mm

MP-3735 ***was $249.00***

$199.00 SAVE $50

NOTE: Suitable for 12V or 24V solar arrays only. A 12V solar array cannot be used to charge a 24V battery.

Mains Power Adaptor with RCD for Caravans

Convert your 15A caravan power lead to fit a 10A power outlet. Features a 10A circuit breaker/RCD in case you accidentally overload the device. Ideal for overnight park on a property that does not have a 15A power outlet.

- Voltage: 240VAC, 50Hz
- Size: 180(H) x 135(D) x 124(W)mm

MS-4044

NEW $79.95

Mains COB LED Downlights

These high quality GU10 mains voltage LED downlight globes feature a 6W "chip-on-board" (COB) LED module that produces over 500 lumens of brilliant light.

- 6W, 240VAC

60˚ Cool White ZD-0625 $29.95
60˚ Warm White ZD-0626 $29.95

NEW $29.95 EA

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/04/2013.

TOOLS

Testers

Multi-Function Circuit Tester

Designed to test the electrical system of 12/24V vehicles and sends voltage to components to test functionality without jumper wires. It also tests polarity, voltage, short/open status, lights and more.

- Size: 240(L) x 78(H) x 40(W)mm

QM-1494

$49.95

Cat III Insulation Tester/Multimeter

Suitable for high voltage insulation testing up to 4 gigaohms at up to 1000V. It also has AC/DC voltage and low resistance multimeter functions. Moulded storage case and holster included.

- 4000 count
- Cat III 1000V
- Analogue/digital display
- Bargraph, backlight, test hold & lock function
- Size: 200(L) x 92(W) x 50(D)mm

QM-1493 ***was $199.00***

$169.00 SAVE $30

Pushbutton Switch

Pushbutton Switch 6A@ 250VAC Neon IP56.

- DPST

SP-0751

NEW $6.95

Slimline Stereo Plugs

Black, slim design, gold plated 3.5mm plugs for audio applications.

3.5mm Stereo Gold Plug
PP-0132 $2.95

3.5mm 4-Pole Gold Plug
PP-0134 $4.95

NEW FROM $2.95

15 Piece Micro Driver Set

Microscopic fasteners with ergonomic colour coded handles for easy identification. See website for contents.

- Drivers 105mm long

TD-2069

$24.95

Keyring Screwdriver

Attach it to your keys. Great for opening some mobile phones, glasses watches, or other gadgetry.

- Size: 57(L) x 4(Dia.)mm

TD-2086

NEW $2.50

Glasses not included

3-in-1 Function Heat Blower and Soldering Iron

Great for general heating, drying, melting, soldering, heat shrinking etc.

- Piezo Ignition
- Up to 500°C
- Size: 148(L) x 35(W) x 23(D)mm

TH-1604

$29.95

Butane gas 150g: **NA-1020** $5.95

Resistance Wheel

Great for experiments or selecting the best resistance for a circuit. Select from 36 values ranging from 5 ohms to 1M ohms.

- Comes complete with leads and insulated alligator clips

RR-0700 ***was $29.95***

$19.95 SAVE $10

1MHz Handheld Function Generator

Produces sine, square, and triangle waveform signals with output frequency adjustment from 1Hz to 1MHz with maximum amplitude of 8Vpp. Features a function to shift between two frequencies over an adjustable period. With a backlit LCD, inbuilt rechargeable battery, and durable rubber surround it is an ideal instrument for testing on the go or in your workshop. See website for specifications.

- Size: 114(H) x 74(W) x 29(D)mm

QT-2304 ***was $199.00***

$179.00 SAVE $20

Economy Non-Contact Thermometer

Safely measure temperature in hot, hazardous, or hard to reach places with the built-in laser pointer directed at the surface. Provides several readings within seconds. Compact and easy to use with carry case included.

- 8:1 Distance to spot ratio
- Auto data hold
- Temperature range: -30°C to +260°C
- Size: 131(H) x 96(W) x 35(D)mm

QM-7215

$49.95

Soldering Needs

Temperature Controlled Soldering Iron

Adjust the temperature between 200 - 450°C using the dial on the handle, high enough for silver soldering if needed.

- 30W 240V
- Plated long-life tip

TS-1540

$29.95

Spare tips available separately **TS-1542** $4.95

Pro-Gas Soldering Tool Kit

A portable, self-igniting butane powered gas soldering iron tool kit that produces a 1300°C adjustable flame for low end brazing, tin/plastic melting, automotive repair work, welding and heat shrinking. Plastic carry case included.

- 80-100 min operating time
- Torch size: 236(L) x 37(D)mm

TS-1113

Spare tips & butane gas available separately.

$69.95

Goot Soldering Station

Precision, Japanese manufactured instrument with excellent temperature stability and anti-static characteristics. It has a digital temperature adjustment from 200 to 480°C at 65W and a lightweight soldering pencil. See website for full specifications.

- Power: 70W
- Operating voltage: 24VAC
- Control size: 146(L) x 115(W) x 98(H)mm

TS-1440

$299.00

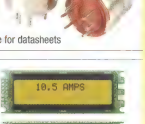
Carbon Dioxide Gas Sensor

Use in a variety of applications such as air quality monitoring in traffic tunnels, fermentation process control, fire control systems, mining etc.

- Good CO_2 sensitivity
- Operates over wider temp/humidity range
- Long term stability and reproducability
- Element behind stainless steel mesh

RS-5600 ***was $59.95***

$29.95 SAVE $30



Also available: ***Gas Sensor Alcohol Fume*** **RS-5605** $13.95

See website for datasheets

LCD Panel Meters

See website for specifications

LCD Panel with Wide View Angle
A wide viewing angle of standard 16 character with a 2 line LCD display.

QP-5517 ***was $24.95 now $14.95 save $10.00***

LCD Panel with Backlit
Featuring a LED backlight, wide viewing angle of standard 16 characters with 2 line LCD display.

QP-5518 ***was $29.95 now $19.95 save $10.00***

Dot Matrix Display
Large character size LCD. Can be viewed from further distances.

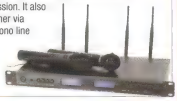
QP-5520 ***was $39.95 now $24.95 save $15.00***

FROM $14.95 SAVE $10

HOME ENTERTAINMENT

Dual Channel UHF Wireless Microphone System

Suitable for professional and stage use, this UHF wireless microphone system features 16 user-selectable channels on each microphone input to provide interference-free transmission. It also has phase locked loop (PLL) circuitry for frequency stability. Output is either via separate balanced line for each channel, or via an unbalanced 6.5mm mono line with the two channels signals mixed. See website for full specifications.



- Mains power supply and 2 microphones included
- Size: 420(L) x 210(W) x 45(H)mm

AM-4120 ***was $349.00***

$299.00 SAVE $50

DVD/CD Player with 5 Disc Changer

Features a 5 DVD/CD changer which enables to load 4 discs while the other one is playing. Mains powered and also has karaoke function.

- USB, SD/MMC card reader for playback
- Component, SVideo and composite video output
- Audio output connectivity
- Size: 496(L) x 416(W) x 152(H)mm

AA-0489

$349.00

Home Theatre Power Board

Protect all home theatre equipment by connecting them to this powerboard as well as current protection via the 10A resettable in-built circuit breaker.

- 8 surge and spike protected outputs
- 2 x USB outputs (Total 2A)

MS-4024 ***was $49.95***

$39.95 SAVE $10

2.4GHz Wireless Amplifier System

Send crystal clear audio from your Hi-Fi or portable music device to speakers up to 20m away without messy wiring. Connect your speakers to the spring terminals and power using the included power supplies or by batteries. Supplied with 2 x 150mm 3.5mm curly cables to connect your audio source.

- Power output: 15WRMS x 2 (into 4 ohms)
- Transmitter and receiver requires 8 x AA batteries each
- Size (transmitter and receiver): 156(L) x 45(H) x 95(W)mm

AR-1895 ***was $129.00***

$109.00 SAVE $20

Play Movies from your Apple® Device

Share and play music, videos from an Apple® device on a big screen. See website for device compatibility.

Docking Station for iPhone® & iPod®

Includes dock with charge port, full function IR remote control, AV & USB cables.

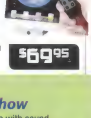
- Composite video and stereo audio output
- 30-pin Apple® connector
- Size: 88(W) x 74(L) x 19(H)mm

WC-7715 iPhone® not included

$39.95

HDMI Docking Station for iPod®/iPhone® & iPad®

Features HDMI video output, stereo audio jack and USB port. The dock includes IR remote control, audio and USB cable and two silicone cases for protection.



- 30-pin Apple® connector
- Supports up to 1080p video resolution
- Size: 72(W) x 68(L) x 28.5(H)mm

WC-7717 iPad® not included

$69.95

Portable Music

Portable Bluetooth® Speaker

Amplify and improve the quality of the audio playing from your device by pairing it to this Bluetooth® speaker. Runs on 4 x AAA batteries (not included) or via USB.

- Wireless range of up to 8m
- Output: 2 x 2WRMS
- Size: 211(L) x 56(W) x 53(H)mm

XC-5205 iPhone® not included

$39.95

Near Field Audio Wireless Speaker

Place your Smartphone or iPod Touch® on top of this speaker to wirelessly amplify the music playing from its loudspeaker. Powered either by batteries (not included) or via USB.

- Output: 2 x 2WRMS, 1 x bass booster
- 5VDC power in
- Size: 155(L) x 71(W) x 38(H)mm

XC-5220 iPhone® not included

$39.95

Ultra Slim LED/LCD TV Bracket

Tilt, pan and swivel for maximum viewing flexibility. Allows 15˚ of tilt and 180˚ of swivel only 32mm from the wall. Solid aluminium and steel construction for stable installation.

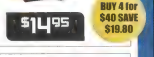
- 642mm at full extension
- Load capacity up to 25kg
- Universal and VESA compliant

CW-2852 ***was $119.00***

$99.00 SAVE $20

HDMI Lead with Rotating Plugs

The plug on each end rotates through 180˚ to accommodate whatever installation challenge you have.



- 1.5m length
- HDMI 1.3 compliant

WQ-7401

$14.95

BUY 4 for $40 SAVE $19.80

House Party

ILDA Animation Laser Show

The unit comes with pre-programmed displays and characters, but with the use of ILDA (International Laser Display Association) software you can add PC control to create cartoon, letters, figures or other characters. Software is not included.

- ILDA software or DMX control
- Control mode: Sound active, automatic, DMX (6 channels), master/slave
- Mains powered
- Size: 270(L) x 80(W) x 174(H)mm

SL-3438 ***was $399.00***

$299.00 SAVE $100

NOTE: This item is NOT AVAILABLE in Western Australia Stores.

Green DMX Laser Show

Produces over 100 green patterns with sound activation or DMX master/slave control. Ideal for bars, clubs, house parties or family functions.

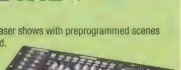
- Mains powered
- Size: 205(L) x 80(W) x 145(H)mm

SL-3436 ***was $169.00***

$149.00 SAVE $20

19" Rack Mount DMX Controller

Control multiple DMX devices, such as lights, dimmers, fog machines or laser shows with preprogrammed scenes such as fade, pan, strobe, colour etc. Rack-mountable and mains powered.



- 9V plugpack included
- Size: 482(W) x 133(H) x 70(D)mm

SL-3429 ***was $149.00***

$119.00 SAVE $30

19" Rack Mount Enclosures

Ideal for studios, PA, sound reinforcement, IT, or phone systems installations, with a size and configuration to suit any application.

6U Enclosures

HB-5170

- Size: 530(W) x 360(H) x 450(D)mm

HB-5172

HB-5170 ***was $179.00***
now $159.00 save $20

9U Enclosures

- Size: 530(W) x 493(H) x 450(D)mm

HB-5172 ***was $219.00***
now $199.00 save $20

12U Enclosures

HB-5174

- Size: 530(W) x 626(H) x 450(D)mm

HB-5174 ***was $259.00***
now $229.00 save $30

FROM **$159.00** SAVE $20

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/04/2013.

Audio Docks

Portable Stereo for iPhone®/iPod®

Portable, versatile and suitable for use in a small room or on the go. Simultaneously charges the iPhone®/iPod® via USB.

- Dual 2" full range drivers
- Requires 4 x AAA batteries for portable use (does not charge iPhone®/iPod® in this mode)
- 30-pin Apple® connector
- Size: 256(W) x 115(H) x 70(D)mm

AR-1889 Note: iPhone® not included

$69.95

2.4GHz Wireless Stereo Speaker System

Stream audio wirelessly from the base station to the rechargeable speakers. iPhone® and iPod® dock on board and USB transmitter for computer connection. Speaker recharge when placed on the base.

- 2 x 3W satellite speakers
- Dock for iPhone®/iPod®
- Range: up to 30m
- Remote control
- 30-pin Apple® connector
- Base unit size: 335(L) x 148(W) x 28(H)mm
- Speaker size: 120(L) x 107(W) x 129(H)mm

AR-1887 Note: iPhone® not included

$169.00

Portable Presentation Console

eFlash allows you to present common Microsoft Office applications without the need for a computer. It connects easily to a projector or TV and is operated by the included remote control with integrated laser pointer. Presentations are played from an SD memory card.

- Auto slide show
- Displays up to 640 x 480
- Size: 103(L) x 115(W) x 53(H)mm

XC-5405

$54.95

Wi-Fi Remote Wireless IP Camera

The smallest IP camera we've ever seen! With its wireless network interface, the camera allows you to stream and record audio video images over your network or directly to your Smartphone (iPhone® or Android® devices) and laptop on the go. Powered by a CR2 battery (included).

- 640 x 480 resolution
- Size: 30(Dia.)mm

QC-3368

$99.95

Cradle and adaptors available separately **QC-3369** $29.95

QC-3369

Add a Network Port to your MacBook® or Ultrabook™

For MacBook Air®, Ultrabooks, Netbooks and Tablets where USB ports are sparse or RJ-45 network ports are non-existent (ie Macbook Air®). Simply connect a network cable to this device and you have a 10/100Mbps network adaptor.

- Size: 96(L) x 24(W) x 16(H)mm

YN-8407

Laptop and cable not included

$19.95

Portable Power Bank

This unit has a huge 5000mAh capacity and outputs up to 2A so it can charge an iPad® with ease. It allows you to charge 2 devices at once. Unit is rechargeable via USB.

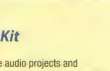
- Included: Apple® connector, micro USB, mini USB
- Output voltage: 5V
- Size: 109(L) x 76(W) x 16(H)mm

MB-3644

NEW $59.95

SATA to USB 3.0 Adaptor

A simple way to access files on a SATA hard drive you no longer have installed. This USB 3.0 adaptor will take full advantage of the max speed of SATA (3.0Gbps) for PCs with USB 3.0 port. Combine with the 3.5" HDD enclosure (XC-4652) for an easy, convenient backup solution.



- Backward compatible with USB 2.0
- Compatible with Windows, Mac® and Linux
- Includes USB 3.0 cable and mains adaptor

XC-4149

NEW $34.95

Pen Style RF Presenter with Laser Pointer

For professionals who frequently use power point presentations. You can cycle back and forward through slides, blank the screen, or use the units laser to highlight key points in presentations. Integrated into a pen unit for easy transportation and usage.

- Compatible with Windows and Mac®
- Sizes: 133(H) x 22(W) x 17(Dia.)mm

XC-5410

NEW $34.95

Wireless Networking

Wireless-N Broadband Router with 4 ports 150Mbps

A Wireless-N router with a wireless access point function combined with the flexibility of a 4-port switch, and a built-in firewall. Provides up to 3 times the transmission rate and double the range of 802.11g products.

- Setup Wizard for easy configuration
- Supports UPnP and DDNS
- Detachable antenna

YN-8305

$44.95

Wireless Broadband Router

Offering the latest in high speed technology, this excellent router can realise data transfer rates up to 300Mbps and achieve three times the transmission range of 802.11g systems. Integrates a router, wireless access point, four-port switch, and firewall all in one compact package. See website for full specifications.

- 802.11n, 802.11g, 802.11b protocols
- 300Mbps receiving and 150Mbps transmission rates

YN-8300

$69.95

Jaycar - No. 1 for Kits

Jacob's Ladder MK3 Kit

Ref: SC Magazine Feb 2013

A spectacular rising ladder of bright and noisy sparks for theatre special effects or to impress your friends. This improved circuit has even more zing and zap than it's previous design from April 2007 and requires the purchase of a VS Commodore 12V ignition coil (available from auto stores and parts recyclers). Kit supplied with silk-screened PCB, diecast enclosure (111 x 60 x 30mm), pre-programmed PIC, PCB mount components and pre-cut wire/ladder. Powered from a 12V 7Ah SLA or 12V car battery (not included).

KC-5520

$49.95

'The Champion' Audio Amplifier Kit

Ref: SC Magazine Jan 2013

Suitable for general-purpose audio projects and supports microphone and electric guitar input. It uses the AN7511 audio IC to deliver 2W music power into 8 ohms from a 9 to 12V supply. Features low distortion, two inputs (mixed 1:1), mute and standby control. Power from 4 - 13.5VDC. See website for specifications. Kit supplied with silk-screened PCB, heatsink and PCB mount components.

- PCB: 101x41mm

KC-5519

$19.95

Garbage and Recycling Reminder Kit

Ref: SC Magazine Jan 2013

Easy to build kit that reminds you when to put which bin out by flashing the corresponding brightly coloured LED. Up to four bins can be individually set to weekly, fortnightly or alternate week or fortnight cycle.Kit supplied with silk-screened PCB, black enclosure (83 x 54 x 31mm), pre-programmed PIC, battery and PCB mount components.

- PCB: 75 x 47mm

KC-5518

$29.95

Jaycar Electronics — Better, More Technical

SECURITY

Network 4 Channel DVR with 4 CCD Cameras

Contains multiplexing DVR with Ethernet access, four weatherproof CCD cameras with IR illumination, and four 20m cables. Ideal for any small business or residential location. Allows remote access viewing from anywhere with an internet connection using a web browser or Smartphone.

- 704 x 576 D1 resolution @ 100fps
- 500GB SATA Hard disk
- 520TV line cameras
- CCD cameras provide clearer images at night time
- DVR size: 343(W) x 240(D) x 68(H)mm

QV-8108 ***was $749.00***

$649.00 SAVE $100

Hidden Camera Mirror

Designed for use where concealed high security is the main requirement such as retail stores, offices, ATMs, museums etc. Looks like a simple convex security mirror but embedded behind is a 600TVL security camera.

- 12VDC required - use MP-3011 $19.95
- Image sensor: 1/3" colour Super HAD CCD
- Size: 350(Dia.) x 200(H)mm

QC-8631

NEW **$199.00**

HD Car Event Recorder with LCD & GPS

Mounts to the car windscreen to record vision, audio, GPS coordinates and car speed to an SD memory card (available separately), which can be played back on the 2.4" colour screen or a PC. Features HDMI output, infrared LEDs to improve night time recording.

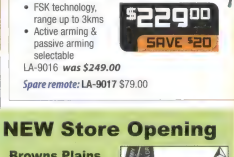
- Built-in G-sensor
- 720p / H.264 / AVI or MP4 compression
- Support microSDHC cards up to 32GB
- 95 degree wide angle lens

QV-3793

$199.00

Car Alarm with Coded Disarm and Rechargeable Remotes

This car alarm system minimises risk through it's coded disarm feature. When enabled, it allows the owner to select a 1 - 5 digit pin code that is entered via the remote and is required to disarm the system. The alarm includes battery backup siren and long range back-lit LCD paging remote with integrated rechargeable Lithium-ion battery.



- FSK technology, range up to 3kms
- Active arming & passive arming selectable

LA-9016 ***was $249.00***

Spare remote: LA-**9017** $79.00

$229.00 SAVE $20

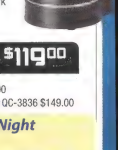
Monitor your Home from your Smartphone

Connect this wireless IP carmera to your Wi-Fi router and access it through a web browser or iPhone®/Android™ app to see what is really going on while you're away. Features Pan and Tilt so you can change the view angle as you please.

- Wired network option
- IR LEDs for visibility in the dark
- 1/5" colour CMOS sensor, 300k pixels
- Size: 125(H) x 100(W) x 95(L)mm

QC-3834

$119.00



Also available:

Wi-Fi IP Camera QC-3832 $89.00

Outdoor Wired/Wi-Fi IP Camera QC-3836 $149.00

Catalogue Out Now!

Purchase over $30 online and get your catalogue absolutely FREE!

Offer valid until 31/05/13

Weatherproof Day/Night Camera

Housed inside a weatherproof case, with the latest dot-matrix IR LED, a fixed 6mm lens and a 600TVL resolution. Using only a single chip, the dotmatrix IR LED provides 120° of horizontal coverage and produces an infrared light output equivalent to the combined output of many ordinary IR LEDs, turning night into day.

- Requires 12VDC 800mA
- Image sensor: 1/3" Colour HDIS CMOS
- Size: 155(L) x 87(W) x 73(H)mm

QC-8627

NEW **$99.95**

USB Mini Inspection Camera

Use a laptop as a monitor to check for termites and other rodents, finding lost tools etc. Features two variable intensity LEDs for illumination.

- Mirror and magnet pick-up tools included
- USB powered
- Size: 10(Dia.)mm x 2m long

QC-3383 ***was $39.95***

$24.95 SAVE $15

Need more length? also available

7m USB Inspection Camera that allows you to get into those very hard to reach places.

QC-3371 ***was $59.95 now $49.95 save $10***

NEW Store Opening

Browns Plains, Queensland

29 Grand Plaza Dr

1800 022 888

Parking available

YOUR LOCAL JAYCAR STORE – Free Call Orders: 1800 022 888

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Kew East Ph (03) 9859 6188
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Midland Ph (08) 9250 8200
Northbridge Ph (08) 9328 8252
Rockingham Ph (08) 9692 8000

Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details.

Prices valid from 24th March 2013 to 23rd April 2013.

HEAD OFFICE
320 Victoria Road, Rydalmere NSW 2116
Ph: (02) 8832 3100 Fax: (02) 8832 3169

ONLINE ORDERS
Website: www.jaycar.com.au
Email: techstore@jaycar.com.au

Jaycar Electronics — Better, More Technical

PRODUCT SHOWCASE

Verbatim launch Portable Power Packs to power portable devices

Verbatim has unveiled its lineup of Portable Power Packs, which will allow users to talk longer, listen to more music, play more games and watch more videos without worrying about running out of battery.

Available in multiple capacities and styles, including a 10,000mAh model, Verbatim's Power Packs extend battery life, making them ideal for business or leisure travel, road trips, outdoor excursions and more.

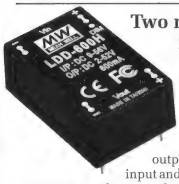
The Power Packs feature a slim design for ultimate portability while still packing enough battery power to charge even the most draining devices. Various devices can be attached from iPods and iPads, Blackberrys and Kindles through to Bluetooth adaptors, etc.

The range includes a 4 x AA Power Pack (you choose the cells to put in it), an Ultra-Slim Power Pack (credit card sized) with a 1200mAh lithium polymer battery, a Portable Power Pack with 2200mAh lithium-ion battery and micro-USB charging cable and a 10,000mAh lithium-polymer Dual USB Power Pack featuring a dedicated iPad port and an additional USB port for simultaneous charging.

Recommended retail prices range from $24.95 through to $99.95

Contact:
Verbatim Australia Pty Ltd
Unit 6, 450 Princes Hwy, Noble Park Vic 3174
Tel: (03) 9790 8980 **Fax:** (03) 9824 7011
Website: www.verbatim.com.au

Two new LED Drivers from Mean Well



MEAN WELL has announced two new encapsulated module DC-DC Buck converters for LED driving purpose, the LDD-L and LDD-H series.

With constant current mode output, LDD-L features 9~36V DC input and 2~32V DC output while LDD-H possesses wide range of 9~56V DC input and 2~52V DC output. Both provide multiple output current options of 300mA/350mA/500mA/600mA/700mA/1A (LDD-H only) for LED system designers to choose from.

LDD series are designed to be mounted on the system PCB of lighting fixtures. Their typical deployment is to connect to the output of CV (constant voltage) mode AC-DC LED power supply for providing a constant current to drive LEDs.

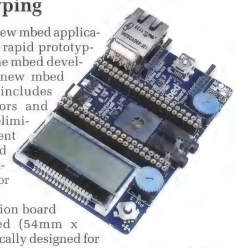
They can maintain good current balance for each LED string and hence ensure the long life of LEDs but can also save the effort of sorting the Vf value of LEDs.

Failure in any LED string driven by the LDD series won't affect the others, and each string can be connected to a different number of LEDs according to system design requirements.

With non-isolated Buck topology design, the LDD series possess an extremely high efficiency, up to 97%.

Contact:
Power Supplies Australia
21 Garden Bvde, Dingley Village, Vic 3172
Tel: 1800 632 693 Fax: (03) 9551 6977
Web:www.power-supplies-australia.com.au

mbed application board supports rapid prototyping



RS Components' new mbed application board supports rapid prototyping. Based around the mbed developer platform, the new mbed application board includes a host of connectors and external interfaces, eliminating the requirement for add-on boards and thus reducing valuable design time for engineers.

The new application board is credit-card sized (54mm x 86mm) and is specifically designed for use with the mbed NXP LPC1768 microcontroller module. Providing multi-functional capability, the new board enables the maximum number of potential experiments and projects, while retaining board footprint at a minimum.

The mbed application board offers an impressive array of features including a 128 x 32 graphics LCD; a 3-axis accelerometer; temperature sensor; servo-motor headers; PWM controlled LEDs; socket for ZigBee, Wi-Fi and Bluetooth wireless connectivity; Ethernet and USB connectors; and a speaker and I/O audio jacks.

Contact:
RS Components
25 Pavesi St, Smithfield NSW 2164
Tel: (02) 9681 8558 **Fax:** (02) 9681 8614
Website: www.rsaustralia.com

SERVICEMAN'S LOG

Curly jobs: you have to be on guard

Dave Thompson*

Every serviceman knows all about "curly jobs". Curly jobs are those that look simple enough to begin with but then, for whatever reason, turn into a can of worms once you get into them. Here are a few of my experiences.

We've all taken on a job thinking that it would be routine only to have it end up really testing our mettle. The bloody-minded among our ranks may even take on jobs they know are (or are likely to be) rather difficult as a kind of professional challenge. After all, if they can fix the curly ones, they can cope with anything – or at least, that's the thinking.

Others may be forced to take on difficult jobs simply because, in the current economic climate, they aren't in a position to turn work down. Either way, we all have to deal with curly jobs and, of course, the clients that bring them to us. And sometimes, unfortunately, it's the client that's the more difficult to handle.

Curly jobs don't necessarily have to be technically tricky either; the job itself might be straightforward but it's the circumstances surrounding it that makes it difficult. I'm sure all servicemen will know what I am talking about and have their own stories to tell. In the meantime, let's look at some examples I've encountered in the computer repair business.

This first example is a classic "curly client" job. Some time ago, a long-term client of ours brought in a laptop for repair. Our usual procedure is to fire the machine up on the reception counter, discuss the exact problems with the client, write everything down and have them sign off on it. Only then do we set about repairing whatever it is we have agreed ails the machine.

In this case, my staff member had spoken to the client by phone about this particular laptop's problems and just happened to be dealing with another customer when the client brought it in. So instead of following normal procedures, he simply took the laptop and put it straight on the incoming jobs shelf without checking it out with the client first. However, when he subsequently started work on it later that day, he found that it was completely dead in the water and wouldn't power up.

After trying everything he could think of to get it to power up, he called the client and informed him that we couldn't get it to work at all. Unfortunately, the client immediately launched into the "well, it was working when I left it there so you guys must have done something to it" speech – a speech I've heard all too often over the years.

Hail to the chief

As the chief, I was then told by my employee that the client wanted to talk to me and from that point on it became my problem. In my first conversation with him, I played it straight and calmly outlined the facts as we knew them, ie, that the machine was dead when presented to us and that we'd done nothing at all to it other than to plug it in to the mains with the power supply provided to try to get it working.

It cut no ice – the client immediately became very agitated and reiterated what he'd already said to our staff member, only this time his message was liberally sprinkled with profanity and not-so-subtle legal threats. From then on, there was no talking to this client; no amount of remonstrating made any difference and all requests for him to refrain from using threatening and offensive language only invoked more of the same

By now, my serviceman's radar had well and truly lit up and the alarm bells were ringing. This whole scenario was a bit too contrived and I began to get the feeling we were being set up. Customers (if you could call them that) had tried things on like this before over the years, which is why we implemented the system we have. It's designed to ensure that everyone involved understands exactly what the fault is when the machine is brought

~HIS MESSAGE WAS LIBERALLY SPRINKLED WITH PROFANITY & NOT SO SUBTLE THREATS...

in, along with a signed agreement on this and the work to be done to resolve it

In other words, there's no room for surprises, no misrepresentation and no room for reinterpretation of what was said sometimes weeks or months after the fact.

It's a system that works quite well. In the past, I've dealt with several customers who'd brought in a computer claiming that it had some minor issue. But then, when we set about plugging it in so that we could fire it up on the reception counter, they suddenly got rather fidgety and started back-tracking on what they had told us about the fault.

When the machine doesn't power up or has more serious symptoms than they've described, they then act surprised but it's not hard to tell when someone is acting. In each case, I'm left with the feeling that if we hadn't gone through this process, they would have tried the same "it was working when I dropped it off . . . " routine on us.

It's a shame we have to go to such lengths to protect ourselves but the sad fact is there are people out there who attempt to manipulate small business owners in order to wrangle free service or compensation.

My fears in this example were confirmed when we stripped the covers off the laptop and discovered a considerable amount of coffee had been spilled into it. That's never a good recipe for continued operation, as anyone with any knowledge of electronics can tell you.

Judging by the amount of residue and the extent of the corrosion on the motherboard, this spill was probably several months old by the time the machine came to us. And since it was centred on the power supply components on the motherboard, this was the most likely section to have failed.

Armed with this new evidence, I went back to the client and asked him about it. At first he acknowledged that there had been a spill but he claimed that the machine had been immediately dried out in an airing cupboard and since it was working fine afterwards, the spill couldn't be the problem. Besides, he had since asked people who "know about computers" and had been told that it wouldn't have anything to do with the computer not working now.

I informed them that it was very likely to be the cause of the problem and it was typical of spills that, over time, corrosion gradually eats away at the components until they fail completely. I also told him that because of this, we couldn't do anything about the machine except replace the motherboard at his cost.

Of course, this went down like a lead balloon, resulting in the client again threatening legal action. Eventually, he did take us to court and we thought we had a pretty good case, providing plenty of photographs and years of expert experience.

However, on the day, the client claimed he knew nothing of any liquid spill and denied ever having admitted to knowing about it or even talking to me about it. So, in the absence of any recorded telephone calls, it was my word against his. Surprisingly, the court found that (a) if there was coffee in the laptop, we (not the client) must have introduced it; and (b) we didn't provide convincing evidence that coffee, or any liquid for that matter, damages laptop motherboards!

As a result, they awarded the client full original retail replacement cost of the laptop, which by that time was well over two years old.

Our appeal was thrown out on a technicality, making this the worst job I've ever dealt with. It's certainly an experience I don't want to repeat and my staff are now instructed to stick rigidly to procedure. I've also implemented a further measure to protect myself; all potentially difficult conversations are now recorded, with the client's acknowledgement, using audio for phone conversations and both audio and video if the client is at the workshop.

Of course, we won't be dealing with that particular customer ever again –

Items Covered This Month

- Curly jobs: be on guard
- Electron microscope repair
- Boeing 747 ABS warning system
- Star SA-30 valve amplifier

**Dave Thompson, runs PC Anytime in Christchurch, NZ.*

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Software problems

Another very common example of a job turning curly is where a customer brings in a computer for repair but doesn't have any original disks or license keys for the software installed on the machine. We don't usually require this stuff for simple repair jobs but if a full system re-installation is necessary, then we do need legitimate license keys for the likes of Windows, Microsoft Office, Adobe Photoshop and other copyrighted software. The problem here is that many vendors stopped supplying physical disks or installation media with their computers a long time ago, so most people don't have this information and many are not even aware they need it.

In the old days, computer buyers usually received a disk for the Windows operating system installed on the machine, along with various device driver disks and sometimes even a hard-copy user manual for some of the hardware. Due to rising costs and falling profits, this practice was soon abandoned in favour of pre-installed or downloadable software with no physical media on offer.

Operating system installation files were sometimes stored on the hard disk and sometimes not. Some manufacturers even provided a separate recovery partition on the hard drive, containing an image of everything installed on the machine. Manuals, if issued at all, came in PDF or RTF format and were found tucked away in support folders somewhere on the drive.

So you can easily see the potential problem; what if the hard disk fails? How are we supposed to reinstall the system software in such cases?

Then there's the software license key conundrum; most people running a Windows-based computer will have access to their license key whether they are aware of it or not. In accordance with Microsoft's end-user agreements, all computers running pre-installed versions of Windows must have a Windows license key stuck to the case of the machine somewhere, tying that copy of Windows to that particular computer. On a desktop machine, the sticker is usually somewhere on the side of the case, though some vendors have been known to stick it on the bottom of the case or on the rear panel. On laptops, the sticker is usually placed on the bottom of the machine, next to the manufacturer's label showing the model and serial numbers.

However, attaching the license key sticker on the outside of the computer, in full view, presents potential problems. Even though Windows is reasonably priced, there are plenty of people out there who don't want to pay for it. These people will borrow someone else's disk to install Windows on their machine or they may even purchase a pirate copy for $5 during an overseas holiday.

However, many pirate copies of Windows will not activate. That's because, to activate the installation, Windows "phones home" over the Internet and subsequently checks again every now and then to confirm everything is as it should be. If it finds that the key has already been used, it complains about the copy not being genuine, increasingly nagging the user to purchase a legitimate version and enter a new key so it can be validated. If not, it will eventually stop working properly.

Many people in this situation will try to find a key from the web or use some kind of crack or key generator. This may or may not work and could even fill your machine with nasty bugs and end up costing more to fix than a legitimate copy of Windows. Either way, this is obviously illegal and constitutes software piracy.

Which brings us back to the sticker on the outside of the computer; if a pirate suddenly needs a valid key, all they have to do is head down to their local computer superstore and get one from one of the display machines. The keys on display are, after all, working licenses and some may not have been activated. Fortunately, most retailers and vendors have gotten wise to this but it is still something to be aware of.

I encounter the lost-key scenario most with laptops, where the Windows license key on the bottom of the machine has literally been worn bare by someone's knee. There are obviously the remains of a valid license sticker (unless the machine's owner is an especially clever fraudster) but it is of no use to us because the key is no longer readable.

Fortunately, if the hard drive is still alive and the Windows registry intact, we can retrieve the license keys not only for Windows but also for Microsoft Office, Works, FrontPage and other software the client may want reinstalled. However, we are still on legal thin ice; just because someone has a Microsoft Office key in their Windows registry doesn't necessarily mean they've purchased the software. If they purchased the key online, the only proof of purchase may be an email from the vendor they bought it from, which may or may not be recoverable.

If the client is thorough enough, they may have printed it out and kept it but how many of us do that? There's also the possibility that they have borrowed a mate's disk and installed the software from that. Microsoft and other vendors usually allow two or three activations from the same product key (if it is a single-license product) before the activation process becomes more stringent and some explaining to a real person is required.

In such situations, we usually accept any recovered keys on face value and trust that the client is telling the truth when they say they purchased the software. However, I've had more than a few cases where the client is a little vague about ownership or I recognise the keys recovered as being widely distributed illegal licenses.

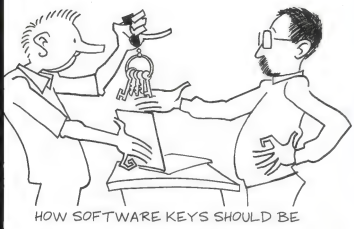
And that's where things get difficult; in such cases I have to tell the client I cannot reinstall their product because

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column? If so, why not send those stories in to us?

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.



HOW SOFTWARE KEYS SHOULD BE

the key is not legitimate. How this news goes down all depends on the client but I've found most people are OK with it and will pay for a bona-fide copy of Windows or Office.

But what to do in cases where the client has no media or licenses, the sticker has worn away and the hard drive has died, making any key retrieval impossible? This is a terrible situation because 99% of the time we know the owner had a valid license for the product but without that key, we cannot legally reinstall the software.

Calling the computer manufacturer is no help because they don't keep a record of what key goes with what machine and unless the owner has had cause in the past to write it down somewhere, there is no possible way of knowing what it is. This is a call the individual serviceman has to make; some will flatly refuse to reinstall the operating system, requiring the client to buy another copy, while others might use a license key taken from a dead computer, reasoning that the inactive computer won't be using it and since the client did have a legitimate key, it all evens out.

It's a tough call and one that proves just how the curly jobs keep us on our toes. Handled properly though, these jobs can be some of the most rewarding, so it would be a dull serviceman who avoids them completely.

Electron microscope repair

Sometimes, it takes only a minor component failure to stop expensive gear in its tracks. This story, from A. W. of Glen Iris, Victoria, describes how a 10-cent part laid low a million dollar electron microscope . . .

I read in a recent Serviceman article in SILICON CHIP that ceramic capacitors "are much more reliable than electrolytics but can still give trouble". That reminded me of an interesting experience I had some years ago.

At that time, I was engaged in research using a high-resolution transmission electron microscope (TEM) and was responsible for the electron microscopy area. The TEM had sub-nanometre resolution and required highly-stable accelerating voltage and electron lens current supplies to achieve this.

One day, it developed a fault that resulted in a fluctuating focus of the electron image, making the TEM unusable. My immediate thought was that this was due to a high-voltage instability, since we had observed similar symptoms in the past.

The 200kV accelerating voltage was generated in a volt-

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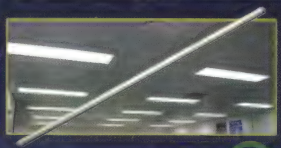

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Serviceman's Log – *continued*

A Simple Fault But Difficult To Find

Simple faults can sometimes be difficult and time-consuming to track down. And if it's in an aircraft, it can be very expensive as well. J. C. of Cronulla, NSW has a story on one such fault in a Boeing 747 . . .

Anyone who has any knowledge of modern transport aircraft will know that they are quite complex beasts, full of systems which sometimes have the knack of failing in unusual and unpredictable ways. Many people in the aircraft industry can no doubt relate tales of complex failures but here is the story of how a simple fault in the cabin wiring system had a serious impact on an apparently-unrelated operational system.

The aircraft in question was a Boeing 747 and the operational system was the brakes – very much an airworthiness system and critical to the safe operation of the aircraft. The fault led to delays and aircraft downtime costing over $100,000.

As a background, all large passenger aircraft since the 1950s have been fitted with anti-skid systems, the forerunner of the automotive ABS. This system monitors the speed of all 16 braked wheels, releasing and re-applying the individual brakes as required to prevent skidding and losing braking effectiveness during landing.

The problem in this particular aircraft started not long after it had completed a heavy-maintenance visit and involved an anti-skid fault-light illuminating during taxi. In cases such as this, if the fault cannot be rectified, the aircraft is subjected to a severe weight penalty to ensure that safe braking performance is available, without risking wheel locking, reduced braking performance and possible blown tyres. The end result was the offloading of passengers and/or cargo – a very expensive consequence.

The worst nightmare for any maintenance person is an intermittent fault. In this case, the fault never once appeared whilst the aircraft was in maintenance – it only appeared during taxi for take-off or on taxi back in to the airport terminal on arrival.

Early rectification attempts involved replacement of the most likely components, including the parking brake valve, the anti-skid control unit and associated relays. And because the defect had started not long after a heavy maintenance visit, a thorough search of the records detailing the work performed during the visit was carried out. No evidence of any work in the anti-skid area was found, however.

Continuing reports and delays then saw further components replaced, including the anti-skid fault light assembly itself. The aircraft was then subsequently grounded for three days while the complete anti-skid light wiring from the cockpit to the wheel-well was replaced

But despite the work done and the involvement of several maintenance crews and engineering specialists, the defect continued to be reported almost every flight. In most instances, the fault caused a delay and/or operation with the anti-skid system rendered inoperative, with the associated heavy-weight penalty and revenue loss.

Finally, after further analysis, the fault was isolated to a wiring error in a toilet door switch! How could this be? To understand, you need to know a little about the functioning of the toilet door switch.

Basically, the slide which locks the toilet door operates a switch which transfers power to the toilet lighting. This ensures that the light is on when the door is closed but turns off when the door is unlocked to minimise disturbance to nearby passengers in the night.

This same switch also allows the

age multiplier stage that was contained in a dry Freon-filled tank. The TEM was so sensitive to voltage changes that this tank was on a vibration isolation pad – even slightly rocking the tank produced enough capacitance change to affect the electron image.

Anyway, there were a number of possible sources of high-voltage instability, including tracking over "dirty" ceramic insulators. However, thoroughly checking and cleaning the high-voltage sections of the supply failed to cure the fault.

My attention then moved to the next possible problem area. A TEM has a number of magnetic lenses that are driven by variable constant-current sources. The most critical of these is the current source for the objective lens that is the main image-forming lens. Careful investigation uncovered noise on the supply to this lens but the question then was, what was causing it?

As luck would have it, the objective lens current-control circuitry is difficult to access, consisting of a number of parallel transistor current sources immersed in an oil-filled tank. However, before doing anything else, the circuit was first examined to determine which components were most likely to cause the observed symptoms, the most obvious possibility for the introduction of noise being a failing semiconductor.

That done, the circuit was pulled out and cleaned up. We then started checking back from the output to see where the noise was being introduced. This isolated the problem to a driver transistor stage that essentially consisted of a transistor, a ceramic filter capacitor on its base and a couple of resistors.

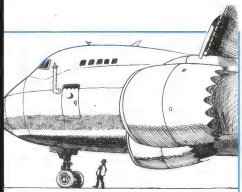
I was reluctant to dive in and pull out the transistor, which was a little awkward to remove, so I first replaced the 1nF ceramic filter capacitor (despite the fact that I had always regarded ceramic capacitors as being very reliable). And that was it – the problem was fixed! There was no more noise on the supply line and when it was all reassembled, a rock solid image appeared.

Further checking revealed that the capacitor had not completely failed but had gone slightly leaky. So, a 10-cent component had taken a number of days to track down and had stopped the operation of a million dollar electron microscope!

Star SA-30 valve amplifier

L. G., of Cowes, Victoria recently resurrected an old Star SA-30 valve amplifier, making a few improvements along the way. Here's his story . . .

I recently spotted an old Japanese valve amplifier for sale on the net and had a sudden, impulsive thought. What if I overhauled a similar amplifier using modern components and technology; ie, replace all the old capacitors with modern quality units, replace the noisy AC neon indicator



lighting to be permanently on while the aircraft is on the ground and, due to a wiring error during maintenance, a combination of power sources were being inadvertently connected together when the cabin crew locked the toilet door open for take-off. The end result was 115V single phase being fed to one phase of a 3-phase power supply.

This power supply normally supplies regulated 28V DC to various circuits when the aircraft is on the ground as well as in flight. However, the single-phase input to one phase of the 3-phase supply resulted in an output of about 10V DC from the supply which was enough to power some of the circuitry but not enough to energise a monitor relay which removes power to the anti-skid failure warning light.

So it was an extremely frustrating and expensive fault. Once isolated though, it was a 10-minute fix!

with a DC operated LED, and replace all the screen and grid-leak resistors with low-noise metal oxide ones?

Valve amplifiers in those days also suffered from annoying hum and a fair bit of induced background noise. So why not use DC current to supply all the filaments as well?

With that thought in mind, I rang a mate who once owned a Star valve amplifier and now regretted having ever sold it. After a little sleuthing, I found out that the Star was a rebadged Lafayette design which came either as an LA224A (using 6BQ5s) or a LA224B. It was also sold under the Bocama brand.

After some hunting around, another mate eventually located a Star SA-30 amplifier, albeit with a burnt-out mains transformer. This apparently was a common fault, as the export models simply wired the 2 x 115V primary windings in series to give 230V for European operation. In addition, no protection was employed in the DC line to prevent a heavy overload current if an output valve went short circuit. As a result, if an output valve did short, it either killed the output stage or the mains transformer.

Sure enough, when I took a look inside my newly-acquired unit, one of the output valves had that distinctive red-orange burn mark inside, indicating a major short had occurred. So that explained the burnt-out transformer.

By sheer luck, my mate had an original power transformer in his spare parts bin. I duly fitted this, carried out the component changes described above and fitted new valves. This model used 6GW8s (now hard to get) in a push-pull configuration in the output stage, plus the usual 12AX7s for the preamp, tone control and splitter circuits.

It all worked as soon as it was fired up and delivered clean sound. However, where I live, the mains supply varies up to 252VAC and is usually around 248VAC, despite 230V now being the standard. As a result, I installed a 20W dropping resistor in the AC line to bring it back to 230VAC into the transformer.

The problem now was that this resistor ran too hot, despite the chassis mount acting as a heatsink. The output valves were also running too hot and subsequent measurements revealed that the 6GW8 plate and screen voltages were just over 300V DC, whereas the valve bible said they should be 230V DC.

Another 20W dropping resistor, this time in the HT line, fixed the heat problem in both areas. SC

By JIM ROWE

Deluxe GPS 1pps timebase for frequency counters

Were you interested in the precision GPS timebase featured in the February 2013 issue? That was the "no frills" version. Here we present a Deluxe GPS 1pps Timebase which also suits our recently described 12-Digit Frequency Counter. It not only provides the same near-atomic-clock-accuracy 1pps pulses for the counter's timebase but also extracts the NMEA 0183 data stream from the GPS satellites for processing on your PC.

MEASUREMENT ACCURACY is the prime reason for building either the original no-frills version or this new Deluxe GPS 1pps Timebase. Either of them represents the simplest and most economical way to match the accuracy to the resolution of the 12-Digit High-Resolution Frequency Counter described in the December 2012 and January 2013 issues of SILICON CHIP.

By using a GPS 1pps timebase, the counter can achieve a measurement accuracy approaching ±1 part in 10^{11}. That's up in atomic clock territory.

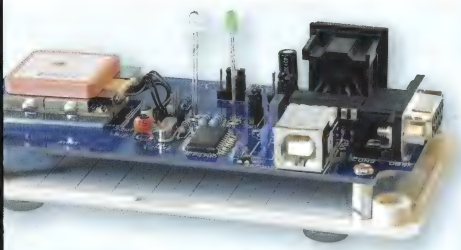
Our February no-frills design comprised little more than a cheap GPS receiver module with the all-important 1pps output, plus a handful of components to provide the module with power and to buffer the output pulses. Despite its simplicity, this first GPS 1pps Timebase works extremely well.

But while it was under development, we also had the intention of describing this deluxe version which would also have the NMEA 0183 stream of navigation data. This data is provided by virtually all low-cost GPS modules, along with the 1pps pulses but separated from them.

So that's the basis of new Deluxe GPS 1pps Timebase described here. The NMEA data is fed out to a USB socket and it's relatively easy to analyse this data stream and extract the current UTC (Universal Time Co-ordinated) and date, along with such things as longitude, latitude, altitude and the number of GPS satellites in view. In addition, the PC can display the signal-to-noise ratio (SNR) of the signals from the satellites and even the quality of the "fix" that the GPS module is currently able to achieve using them. This helps to confirm the accuracy and reliability of the 1pps pulses as a timebase.

GPS clock driver

Back in the June 2009 issue of SILICON CHIP, we described a GPS Clock Driver module. This took the NMEA 0183 data stream from a low-cost GPS receiver module and made it available for driving our May 2009 6-Digit GPS Clock. Alternatively, it could be fed to a PC via a "legacy" serial port. There were a number of freeware and shareware software applications available at the time which could be used



The parts are all installed on a small PCB which is then mounted on the lid of a UB3 jiffy box. The lid then acts as the base of the completed unit shown at left.

to analyse the data stream and display much of the useful information.

So one way of improving the February 2013 GPS 1pps Timebase would be to simply "bolt on" the relevant parts of the June 2009 clock driver circuit, to make the NMEA 0183 data stream from the GPS receiver module available (as well as the 1pps pulses). This would allow the GPS 1pps Timebase unit to drive the May 2009 clock or the serial port of a PC, as well as the timebase of the 12-Digit Frequency Counter.

The problem with this approach is that most of today's PCs don't provide an RS232 serial port; they only have USB ports. So our deluxe unit features a USB port as well as an RS232 port, so it can be connected to a wide range of computers and laptops.

This makes it easy to monitor the receiver's "fix" status by running a freeware application called GPS Diagnostics 1.05 (there are many others but we have found this one to be excellent).

As shown in the accompanying photos, the Deluxe GPS 1pps timebase is housed in a small plastic case. It can be powered via its USB port or from the 12-digit Frequency Counter. The latter approach is appropriate when you are not using your computer to monitor the GPS signal status.

Circuit details

Fig.1 shows the full circuit details of the Deluxe GPS 1pps Timebase. It's still fairly simple but again that's because all the complex circuitry needed to receive the signals from the GPS satellites and derive both the 1pps (1Hz) pulses and the NMEA 0183 data stream from them is buried deep inside the GPS receiver module.

We are again specifying either of two low-cost receiver modules which are currently available from various suppliers: the GlobalSat EM-406A module which is available for as little as $39.90, or the Fastrax UP501 module which is physically smaller but priced at $59.90. The project is also compatible with various other receiver modules, if you find the EM-406A or the UP501 hard to get.

The type of GPS receiver module required is one that incorporates its own ceramic "patch" antenna for the UHF signals from the GPS satellites, while also providing an output for the 1pps (pulse per second) time pulses. It can operate from a DC supply of either 5.0V or 3.3V. A few currently available modules are listed in a panel elsewhere in this article.

The EM-406A has its own built-on GPS patch antenna and operates directly from 5V DC. It features the SiRF Star III high-performance GPS chip set, very high sensitivity and a relatively fast time to first fix (from a cold start).

The UP501 and other compatible GPS modules operate from 3.3V DC, so we have made provision for fitting a 3.3V LDO (low drop-out) regulator (REG1) to provide this lower voltage for modules that need it. In this case, we are using an LP2950-3.3 regulator, which comes in a TO-92 package.

Apart from the power supply arrangements, there is a 40106B hex CMOS Schmitt inverter (IC1), used for buffering both the 1pps timebase pulses for the counter and the NMEA 0183 data stream. IC1c is the buffer for the NMEA data, with its output going to pin 2 of CON2. The other five inverters in IC1 are used for the 1pps pulse buffer and as a level translator, with IC1a used as an optional inverter to restore pulse polarity if necessary. As shown, IC1b, IC1d, IC1e & IC1f are connected in parallel and drive pin 3 of CON1, which goes to the counter's external timebase input.

Parts List

1 UB3 jiffy box, 130 x 68 x 44mm
1 PCB, code 04104131, 121 x 57mm
1 GPS receiver module with in-built patch antenna & 1pps output
4 3-pin SIL pin headers (LK1-LK4)
4 jumper shunts to match
1 12MHz crystal, HC-49US (X1)
1 5-pin DIN socket, PCB-mount (CON1)
1 DB9F socket, PCB-mount (CON2)
1 USB type B socket, PCB-mount (CON3)
1 14-pin DIL IC socket
4 M3 x 10mm tapped metal spacers
4 self-adhesive rubber feet
8 M3 x 6mm machine screws
25 x 25mm double-sided adhesive foam (to secure GPS module)

Semiconductors

1 40106B hex Schmitt inverter (IC1)
1 MCP2200 USB2.0 to serial converter (IC2)
1 LP2950-3.3 LDO regulator (REG1*)
1 NX2301P P-channel Mosfet (Q1)
1 2N7002 N-channel Mosfet (Q2)
1 3mm green LED (LED1)
1 3mm red LED (LED2)

Capacitors

2 10µF 16V RB electrolytic
1 470nF MMC
2 100nF MMC or MKT
1 33pF NP0 ceramic
1 15pF NP0 ceramic

Resistors (0.25W 1%)

1 47kΩ
1 10kΩ
1 1kΩ
3 470Ω
1 22Ω

*Only required if you are using a GPS module which requires a 3.3V supply

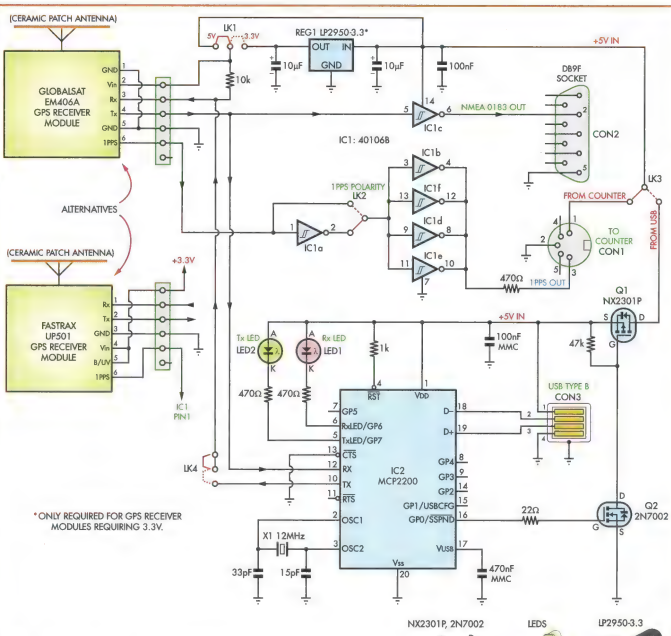


Fig.1: the circuit consists of the GPS receiver module plus a hex CMOS Schmitt trigger inverter to buffer the 1pps (1Hz) pulses and NMEA data from the module. The NMEA data is also fed to IC2 which drives the USB serial port.

As with the no-frills circuit, link LK2 is used to allow the 1pps pulses to be either inverted or not by the buffer, so that their leading edges are positive-going regardless of their polarity out of the GPS module (some modules may output them as inverted).

Basically, we need to ensure that the leading edges of the 1pps pulses fed to the 12-Digit Frequency Counter are positive-going. That's because it's the leading edges of the pulses that are locked closely to the "atomic time" provided by the GPS satellites.

The remaining circuitry in Fig.1 is used to provide the USB serial port. Here we are using a Microchip MCP-2200, a dedicated USB2.0-to-UART Protocol Converter device. It appears to be similar to a PIC18F14K50 microcontroller chip but is "hard wired" to perform USB/serial and serial/USB conversion, so that when it's linked to the USB port of a PC it behaves as a "virtual COM port device".

As a result, Windows will communicate with the MCP2200 via a virtual COM port (VCP) driver. In addition, Microchip has a freeware "Configuration Utility" program which can be used to configure the MCP2200 in terms of baud rate, data format and so on. We will describe this in greater detail later.

The MCP2200 (IC2) needs a 12MHz crystal (X1) for its clock oscillator. This crystal is connected between pins 2 & 3, along with two small NP0 ceramic capacitors. It also needs a 470nF MMC bypass capacitor connected between its V_{USB} pin (pin 17) and ground, together with a 100nF MMC capacitor

bypassing the +5V rail from the PC's USB port (ie, pin 1 of CON3).

The D- and D+ data lines from CON3 connect directly to pins 18 & 19 of IC2, while the NMEA data stream from the GPS receiver module is fed directly to pin 12 of IC2. IC2 converts this data stream into USB packets for transmission to the PC via CON3.

NMEA commands are also sent back from the PC via the USB cable and these emerge from pin 10 of IC2. These can be fed back to the Rx input of the GPS receiver module when link LK4 is used to complete the circuit. In this application, we don't need to send any commands to the GPS receiver module – we simply use its default operating configuration.

However, we found that when this connection was made in addition to the main Tx-to-Rx connection to pin 12 of IC2, there could be a conflict whereby IC2 could prevent the GPS receiver module from finding a "fix". In addition, the GPS receiver could prevent IC2 from configuring and enumerating correctly. So it seems best to leave LK4 in the "open" position, as shown in Fig.1 (and Fig.2).

LED1 (receive) & LED2 (transmit) are driven from pins 6 & 5 of IC2. These LEDs flash when data is passing through IC2 in one direction or the other.

The remaining part of the circuit involves Mosfets Q1 & Q2, which are used to allow IC2 to control the +5V power fed from USB socket CON3 to link LK3 (this link is used to select the power source for the GPS receiver module and IC1). This is done to conform to the USB 2.0 requirement that current drain from the PC's USB port drops to less than 2.5mA when the PC's USB host controller holds the device in "suspended" mode.

IC2's SSPND-bar output (pin 16) is connected to Q2's gate via a 22Ω suppressor resistor, so that Q2 is only turned on when IC2 receives a "wake up from suspension" directive. Then when Q2 turns on, it turns on Q1 which makes the connection between pin 1 of CON3 and LK3. So if LK3 is in the power "From USB" position, (rather than "From Counter" position), the GPS receiver module will only receive power when (a) the project is connected to a USB port on a PC; (b) the PC is powered up; and (c) software is running on the PC and "listening" to the GPS data stream, so that IC2 is not in suspended mode. Note that the GPS receiver module can take over a minute to get a "fix" after power is applied.

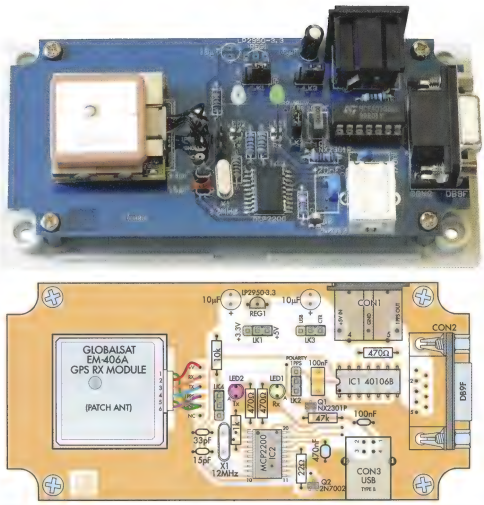


Fig.2: follow this layout diagram to build the unit. Omit REG1 and the 10µF capacitor to its left if you are using the Globalsat EM-406A module and install LK1 in the +5V position. Alternatively, install REG1 and the capacitor if your GPS module requires a 3.3V supply and fit LK1 to the +3.3V position.

Alternatively, be fitting LK3 to the "From Counter" position, the upper part of the circuit can be powered from either the counter or an external plugpack supply (via CON1). This means that you don't have to connect the unit to a PC in order to simply derive 1pps pulses.

Building it

All the parts for the Deluxe GPS 1pps Timebase fit on a PCB coded 04104131 and measuring 122 x 57mm. Fig.2 shows the PCB parts layout diagram, while Fig.3 shows the pin connections for the GlobalSat EM-406A and Fastrax UP501 GPS receiver modules. Note that almost half of the PCB is reserved for mounting the GPS module itself, which is held in place using double-sided adhesive foam.

Begin by fitting SMD components IC2, Q1 & Q2 to the PCB, as it is much easier to do this before any other parts are fitted. Take the usual precautions when soldering these parts, ie, use an earthed soldering iron with a fine-tipped bit. Tack-solder one or two device leads first, so that the device is held in position while you solder the rest of the leads. You then re-solder the original tacked leads to ensure reliable joints.

Don't worry if you accidentally bridge two or more SMD device leads with solder during this procedure. These bridges can subsequently be removed quite easily by pressing solder wick braid against the bridged leads using the tip of your soldering iron. This sucks up the excess solder while leaving the solder joining the leads to the PCB pads underneath in place.

Once the SMD parts have been installed, add the SIL pin headers for links LK1-LK4, followed by the resistors, capacitors and the 12MHz crystal.

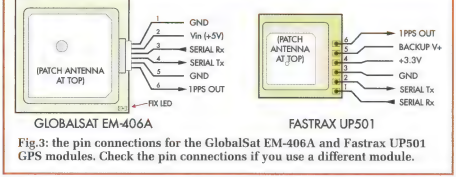


Fig.3: the pin connections for the GlobalSat EM-406A and Fastrax UP501 GPS modules. Check the pin connections if you use a different module.

A 14-pin socket for IC1 can then be fitted – make sure it's orientated as shown.

Connectors CON1-CON3 can then go in, followed by LED1 & LED2. The latter are mounted vertically above the PCB, with their leads left at full length so that they later protrude through their matching holes in the case (see Fig.4).

Voltage regulator option

Regulator REG1 and the 10µF electrolytic capacitor to its left are installed only if the GPS receiver module you are using requires a 3.3V DC supply rather than a 5V supply. This means that if you are using the EM-406A module, you won't need to fit REG1 or that 10µF capacitor.

By contrast, the regulator and the capacitor must be installed if you are using the UP501 receiver module, since this runs off 3.3V. The same goes for the Digilent PmodGPS and RF Solutions GPS-622R GPS modules.

The GPS receiver module is installed last but before doing this, you need to make the connections between its output pads (or lead wires) and the relevant pads on the PCB (ie, just to the left of LK4). Fig.3 shows the outputs for the Globalsat EM-406A and Fastrax UP501 modules. Be sure to connect these to their matching pads on the PCB.

The EM-406A module comes with a short 6-wire ribbon cable fitted with a sub-miniature 6-pin plug at each end. One of these plugs connects directly to the EM-406A's output socket. The plug at the other end of the cable is cut off and the six wires stripped and tinned before soldering them to their PCB pads.

By contrast, the UP-501 module just has a row of pads along one edge of its PCB. It's connected by first cutting six 25mm-lengths of light-duty hookup wire (eg, from a ribbon cable), then carefully stripping and tinning all the wire ends before soldering the leads into place.

Don't forget to match the output leads from the GPS module to the PCB pads (see Figs.2 & 3), as the connections are not "straight through".

Once all the connections have been made, the GPS receiver module can be secured to the top of the PCB using a 25mm-square piece of double-sided adhesive foam – see Fig.4. Make sure you attach the module with its patch antenna facing upwards – it won't work very well if it faces downwards!

Fitting the links

LK1's shunt position depends on the supply voltage (5V or 3.3V) required for the GPS receiver module you're using, while LK2's position depends on the polarity of the 1pps output pulses from the GPS receiver. In most cases, LK2 will need to be to the lower position (ie, nearest Q1).

LK3's position depends on just how you plan to power the GPS receiver module and IC1 (ie, the 1pps timebase section of the circuit). If you only intend using this part of the circuit when the unit is connected to a PC via a USB cable, then LK3 can be fitted in the USB (lefthand) position (ie, the circuit is powered from the PC's USB port).

Alternatively, if you want to use this part of the circuit continuously (eg, whenever the 12-Digit Frequency Counter is on but without having to fire up the PC), you'll need to fit LK3 in the righthand CTR (From Counter) position and power the unit either from the counter or an external 5V plugpack via CON1.

Finally, LK4 should almost always be fitted to the upper position, to break the connection between pin 10 of IC2 and the Rx input of the GPS module.

Preparing the box

Fig.4 shows how the PCB assembly is fitted inside a standard UB-3 jiffy box. The completed unit can be mounted near a window to get a good "view" of the sky.

As shown, the PCB is mounted on the lid of the box, which then becomes the base. The main part of the box then fits down over the lid/board assembly, to act as a dust cover.

Fig.5 shows the drilling details for the box. Four mounting mounting holes have to be drilled in the lid to accept the PCB, while two holes must be drilled through the top of the main box section for the LEDs. In addition, you have to drill a hole in the rear side of the box and make cut-outs in the front side and righthand end.

Use a small (eg, 1.5mm) pilot drill

Compatible GPS Receiver Modules

The following GPS receiver modules should be compatible with this project

- GlobalSat EM-406A: 30 x 30 x 10.5mm including patch antenna. Operates from 5V DC with a current drain of 44mA. Provides a 1pps output and a "fix" indicator LED. Rated sensitivity -159dBm.
- Digilent PmodGPS: approximately 30 x 55 x 12mm including patch antenna. Operates from 3.3V DC with a current drain of 24/30mA. Provides a 1pps output and a "fix" indicator LED. Rated sensitivity -165dBm.
- RF Solutions GPS-622R: 43 x 31 x 6mm including patch antenna. Operates from 3.3V DC with a current drain of 23/50mA. Provides a 1pps output and a "fix" indicator LED. Rated sensitivity -148dBm/-165dBm.
- Fastrax UP501: 22 x 22 x 8mm including patch antenna. Operates from 3.3V DC with a current drain of 23mA. Provides a 1pps output. Rated sensitivity -165dBm.

Note that for use in this project, the GPS receiver module should have a built-in ceramic patch antenna and also provide an output for the GPS-derived 1pps pulses. Not all GPS modules currently available provide both of these features.

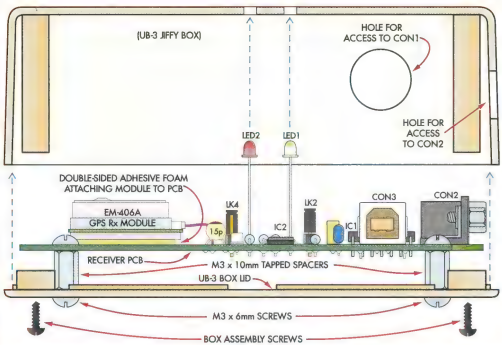


Fig.4 here's how the PCB assembly is fitted inside a standard UB-3 jiffy box. Be sure to install links LK1-LK4 correctly (see text) before securing the top section of the case to the lid. The completed assembly should be mounted near a window to give the GPS module a good "view" of the available GPS satellites.

to start all the holes, then drill the 3mm holes out to the correct size. The hole in the rear side of the box can be enlarged to the correct size (16mm) using a tapered reamer. The two square cut-outs can be made by drilling a series of small holes around the inside perimeter, then knocking out the centre piece and carefully filing the inside edges.

If you are using a GPS receiver module with a "fix" indicator LED, you might want to drill an additional hole in the adjacent side of the box, so that you can view this LED to confirm that the receiver does indeed have a fix. The prototype shown in the photos uses an EM-406A module, which does have such a LED in the lower righthand corner – see Fig.3. That's the reason for the 5mm hole you can see in the front of the box, located 45mm from the lefthand end and 20mm up from the outer surface of the lid.

The UP501 module doesn't have a "fix" LED, so there's no need to drill this hole. However, many other modules do have this LED and the hole location will depend on the LED's location on your particular module.

Once the box holes have been drilled, the PCB assembly can be mounted on the lid on four M3 x 10mm tapped spacers and secured using M3 x 6mm machine screws. That done, check that you've fitted the jumper shunts to each of the four SIL pin headers (for LK1-LK4) as required (see above). The box can then be lowered down onto the lid, taking care to ensure that LED1 and LED2 protrude through their respective holes at the top, and the assembly secured by fitting the four supplied self-tapping screws.

Finally, fit four small adhesive rubber feet to the lid (which now becomes the base) to prevent scratches due to the protruding screw heads. Your Deluxe GPS 1pps Timebase is now complete.

Counter connections

As with the simpler GPS 1pps Timebase unit, only three connections have to be run to the 12-Digit Frequency Counter. These can all be made via a shielded stereo cable fitted with a 5-pin DIN plug which plugs into CON1 of the Deluxe GPS Timebase.

Fig.6 shows the wiring details. One of the inner conductors of the stereo cable connects to pin 3 of the 5-pin DIN plug, to carry the 1pps output pulses, while the other inner conductor connects to pin 1 of the DIN plug, to carry the +5V supply rail for the timebase. The shield braids are both connected to pin 2 of the plug, to link the two grounds.

At the other end of this cable, the 1pps signal lead and its shield braid should be fitted with a BNC plug, to connect to the counter's external timebase input (CON3). The +5V/GND power lead can either be connected to a 5V DC plugpack or fitted with a 2.5mm concentric DC plug which mates with a matching DC power socket added to the rear of the frequency counter.

In the latter case, you will also have to connect the +5V and ground lines inside the counter to the added DC

Other Uses For This Project

The NMEA output of this Deluxe GPS 1pps Timebase can be used with a range of navigation software and free Windows GPS-related software packages.

- For nautical chart and navigation software that works with NMEA-compatible GPS units see: **http://capcode.sourceforge.net/**
- To show your position on Google Maps as you move (multiple options) see: **http://mboffin.com/earthbridge/**

http://download.cnet.com/Google-Maps-with-GPS-Tracker/3000-12940_4-10494227.html?tag=keyword.feed&part=rss&subj=dl.gps

http://blog.geoblogspot.com/2008/09/navigator-101.html

- For a GPS data logger: **https://github.com/javarobots/GpsDataLogger**
- Many more here: **http://www.maps-gps-info.com/fgpfw.html#Windows**

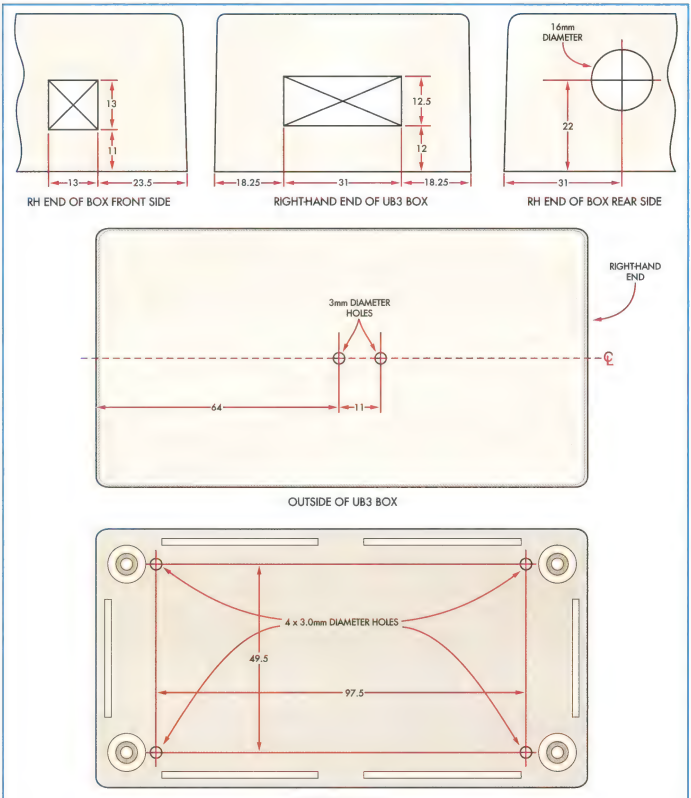


Fig.5: the drilling details for the UB3 jiffy box. The rectangular cutouts can each be made by drilling a series of small holes around the inside perimeter, then knocking out the centre piece and filing to shape.

power socket – see Fig.6. Make sure that LK3 on the timebase PCB is in the CTR (righthand) position if you are powering the timebase section (ie, the GPS module and IC1) from the counter or an external plugpack.

Alternatively, if you intend running the entire unit exclusively from USB power, then you don't need to install this separate supply cable. Instead, it's simply a matter of connecting the Deluxe GPS 1pps Timebase to a USB port on a PC (or a downstream USB hub) using a standard USB cable. Don't forget to set LK3 to the USB position

if powering the entire unit from a USB port.

Configuration

When you first connect the unit to a PC, Windows will respond by installing its standard "virtual COM port" driver. Once it's done that, launch the Device Manager (eg, via Control Panel) and look under "Printers and Devices" to make sure that you now have a "USB serial port". You can then also check its Properties to discover the COM port number and check that it's working properly. You can also set the driver's baud rate to match the GPS module's rate, which is usually 4800bps.

Assuming this checks out so far, the next step is to download and install Microchip's custom MCP2200 Configuration Utility, available from: **ww1.microchip.com/downloads/en/DeviceDoc/MCP2200_Configuration_Utility_v1.3.zip** (5.13MB). Unzipping this provides a self-installing version of the MCP2200 Configuration Utility.

When you run this and then fire it up, you should see a dialog window as shown in Fig.7 – although you won't see any text as yet in the "Output" box. This box will be blank initially, while some of the smaller boxes will have different contents.

Before clicking on the "Configure" button at lower left, you'll need to ensure that the contents of all of the smaller boxes are as shown in Fig.7. You probably won't need to change the contents of the Manufacturer, Product, Vendor ID or Product ID boxes, nor will you need to click on the "Update VID/PID" button. However, you may need to click on the check box next to "Enable TX/RX LEDs", to display the tick as shown.

Similarly you may need to click on the check box next to "Enable Suspend Pin", to display its tick.

If the "Baud Rate" box is not showing "4800", click on the down arrow to its right and then select "4800" from the drop-down list. Then, if the "I/O Config" box is showing something other than "00000000", click inside the box so that you can type in the correct "00000000" text string.

Similarly, if the "Output Default" box is not showing "11111111", enter in that text string yourself.

Now turn your attention to the "LED Function" section at lower right and click on the "Blink LEDs" radio button if this isn't already selected (ie, dis-

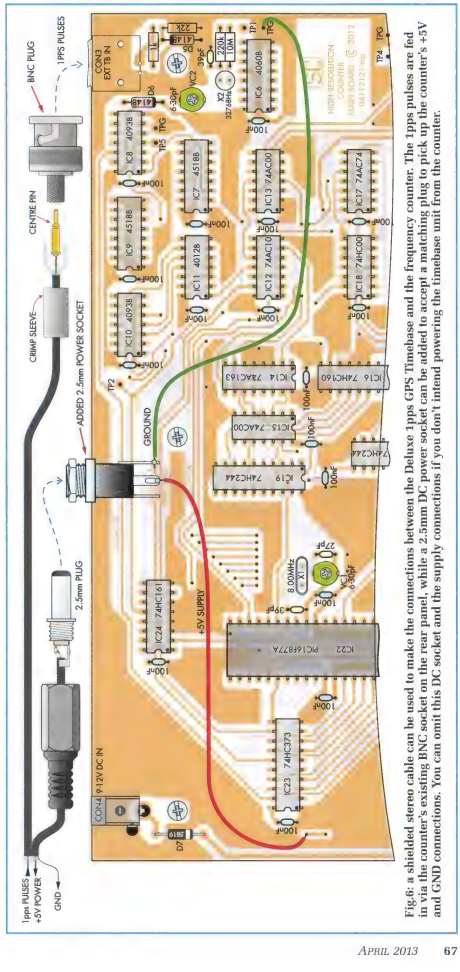


Fig.6: a shielded stereo cable can be used to make the connections between the Deluxe 1pps GPS Timebase and the frequency counter. The 1pps pulses are fed in via the counter's existing BNC socket on the rear panel, while a 2.5mm DC power socket can be added to accept a matching plug to pick up the counter's +5V and GND connections. You can omit this DC socket and the supply connections if you don't intend powering the timebase unit from the counter.

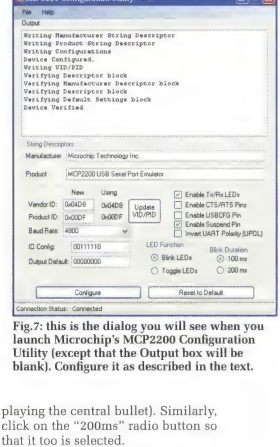


Fig.7: this is the dialog you will see when you launch Microchip's MCP2200 Configuration Utility (except that the Output box will be blank). Configure it as described in the text.

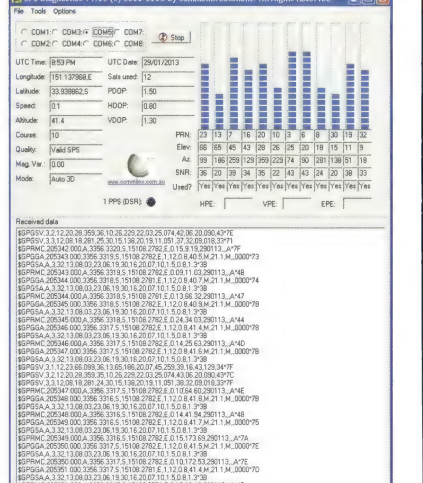


Fig.8: the GPS Diagnostics dialog displays a range of information from the analysed NMEA data, including UTC time, longitude, latitude, altitude, the number of satellites in "view" and the signal strength from each one.

playing the central bullet). Similarly, click on the "200ms" radio button so that it too is selected.

At this stage you should be seeing a display very much like that shown in Fig.7, except that the "Output" window should be blank. If so, you can now click on the "Configure" button at lower left. There should then be a brief pause while the configuration utility "does its thing" with the MCP2200 chip in your Deluxe GPS 1pps Timebase, then the text shown in Fig.7 should appear in the "Output" window. This indicates that the configuration routine has been completed and that the unit is now communicating with the the PC via the USB cable.

Once it's done that, you can then close the Configuration Utility.

Installing the PC software

The final step is to install a software application to allow your PC to analyse and display the useful information carried in the NMEA 0183 output data stream. There are many software apps capable of doing this but one that we particularly recommend is called "GPS Diagnostics V1.05". Developed by CommLinx Solutions, this freeware program can be downloaded from **download.cnet.com/windows**

The quickest way to get to the download page is to search for it by typing its full name in the search box at top right.

Downloading the software is a 2-step process. First, you have to download the customised installer program **cbsidlm-tr1_10a-GPSDiag-ORG-10055902.exe** (620kB). You then run this installer to download and install the GPS Diagnostics program itself.

Once it's installed, launch the program to bring up a dialog window much like that shown in Fig.8. The only differences are that all of the text boxes and bargraphs will initially be blank – including the large box at the bottom labelled "Received data".

Earlier, when you first plugged the USB cable from the GPS Time Receiver into the PC's USB port, Windows installed it as a USB Serial COM port. The allocated port number could then be determined by going to Device Manager and checking under Ports (COM & LPT). Usually, this will be COM3, COM4 or COM5.

Once you've determined the allocated port number, the next step is to select the corresponding port number in the GPS Diagnostics window. That's done by selecting the appropriate radio button at upper left. This tells the program which COM port the incoming NMEA 0183 data stream from the Deluxe GPS 1pps Timebase will be on (in our case, it's COM5).

Analysing NMEA data

You should now find that GPS Diagnostics starts displaying all the

This photo demonstrates the accuracy of the counter when using the Deluxe GPS 1pps Timebase. Here we're measuring a GPS-derived 10MHz frequency and the counter shows 10MHz exactly.

information coming into the PC via that COM port. You'll see the NMEA sentences as they arrive in the large Received Data window at the bottom and within a few seconds, you'll also see the UTC time and date, the longitude and latitude, the altitude of your GPS receiver module and a great deal of other interesting information (see upper right of Fig.8).

It will also show the number of GPS satellites currently in "view", plus a bar chart for each one indicating the approximate signal strength. Under each chart, you'll also see its PRN number, its current elevation and azimuth, its signal-to-noise ratio (SNR) and whether or not it's currently being used. For example, when the screen grab of Fig.8 was captured, our prototype Deluxe GPS 1pps Timebase was able to view and use the signals from no fewer than 12 satellites.

That's a bit unusual though. Most of the time, it will use anywhere between five and nine satellites, while at odd times there may be only three or four in view and usable.

So how do you verify that the unit has a good "fix" and is delivering usable GPS-locked 1pps pulses to your 12-Digit Frequency Counter? That's done in GPS Diagnostics by examining the "Mode" message box. This shows "Auto 3D" in Fig.8, which means that it was able to achieve the highest level of fix when this screen grab was captured.

When you get this message, you can be satisfied that your counter is getting the best possible 1pps pulses.

When the GPS receiver is able to see only a small number of satellites (eg, two or three), the Mode box display can drop back to "Manual 2D". This still indicates that the receiver has achieved a "fix", although some of the navigation information won't be of high quality. However, the 1pps pulses being fed to the counter should still be OK.

It's only time to worry if the Mode message box is blank or showing "No fix", since that indicates that the unit will probably not be delivering any 1pps pulses at all. If that happens, the trick is to try moving the unit to a location where it can "view" more of the sky and therefore "see" more satellites so that it can get a good fix.

In short, GPS Diagnostics is an excellent tool for optimising the position of your Deluxe GPS 1pps Timebase. It also allows you to then monitor the reception conditions on a day-to-day basis. SC

Frequency Counter Measurement Accuracy

IN THE FIRST article describing our 12-Digit Frequency Counter (SILICON CHIP, December 2012), we advised readers that by using a GPS-based external 1pps timebase, it should be possible to achieve measurement accuracy approaching that of an atomic clock. In the specifications panel, we also quoted measurement accuracy with a GPS 1Hz timebase of approximately ±1 part in 10^{11}.

Subsequent testing has quantified the accuracy that can be achieved. Over the last three months, Jim has made measurements using the set-up shown above, with the 12-Digit Frequency Counter fed with an external timebase (using the simpler February 2013 unit for the first five weeks and the deluxe unit described here for the remaining seven weeks). The counter was measuring the 10MHz output from our GPS-based Frequency Reference (SILICON CHIP, March-May 2007) and was set for a gating time of 1000 seconds, so that each measurement took 16.66 minutes. This was done to provide the highest measurement resolution.

The results from this extended testing are: the GPS-locked 10MHz signal from the 10MHz Frequency Reference gave readings of 10,000,000.000 ± 0.003Hz – with a roughly Gaussian or "bell shaped" distribution centred on 10,000,000.000Hz. In other words, a measurement accuracy of ±3 parts in 10^{10} can be achieved.

Note that with this measurement set-up there are three sources of measurement jitter: (1) the GPS module in the 1pps timebase(s); (2) the GPS module in the GPS-based 10MHz Frequency Reference and (3) the inevitable jitter in the PLL (phase-locked loop) inside the 10MHz Frequency Reference itself (used to lock the 10MHz output to the GPS 1pps pulses).

Clearly it isn't easy to separate these three sources of jitter, but with all three present they still allowed us to achieve a measurement accuracy of ±3 parts in 10^{10}. So the true measurement accuracy of the 12-digit frequency counter with the GPS 1Hz timebase is somewhere between ±3 parts in 10^{10} and ±1 part in 10^{11} – still very impressive.

Unless you are measuring an atomic frequency reference, your measurement accuracy is like to be far in excess of the drift and jitter of any source that is commonly available.

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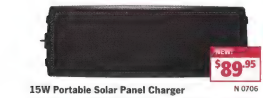

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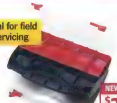

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Ideal for bonding heatsinks to chips, CPU's, high power displays. Note: not designed as a replacement for heatsink compound. 100gm.

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Premium 12V SLA Batteries

Great for security, solar power systems, UPS, comms gear etc.

Capacity	Part	Normally	2 For..
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Not just for PC's. Great for CCTV & home theatre

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Emergency 240V Backup Power Supply.

Powershield Safeguard 750VA UPS. This quality UPS unit will prevent appliance damage caused by power fluctuations or blackouts - PLUS keeps power on during a blackout! Ideal for PC's, security, phone systems & even home theatre! Also equipped with RJ45 phone line surge protection.

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Got one of the latest Apple devices? Pick up a spare charge lead for the office! 1m.

D 2389 NEW! $19.95

LED Light USB Charge Leads

Bright blue LED lights show the power flowing! Available in micro USB or Apple 30 pin dock. 0.9m.

NEW! $17.50 D 2382 Micro USB D 2383 Apple 30 Pin

Stay Charged Up!

About the size of a phone!

NEW! $59.95 D 0506 6000mAh NEW! $24.95 D 0504 2500mAh Due mid-April

Away from mains power? No worries!

These mobile battery banks keep your smartphone or tablet charged up even when you are miles from a 240V outlet. Available in 6000mAh (5V 2A output) or 2500mAh (5V 1A output). 5-7hr recharge time. Includes a range of adaptors, including Apple (30 pin) & Samsung plugs.

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Why pay more? These top quality Powerhouse® lithium batteries offer excellent performance in high power devices.

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Great for caravans & 4WD's

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Prevents damage which can occur to batteries when they excessively discharged by a load. Adjustable cut off 10.4-13.3V. Auto re-connect.

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NEW KIT! $9.95

K 1110

Solar Grasshopper Kit

A life size grasshopper with a solar panel on its back. When he is placed in the sun, his body vibrates back and forth. Ages 8 and up. No tools, soldering or batteries required!

14 Solar Kits In One!

A fun and educational kit designed to assemble 14 different ways to inspire and challenge your kids to learn about solar power and electronics. Includes parts to build a snake, dog, crab, boxer, turtle, row boat, beetle and more! No soldering or special tools required. Ages 8 and up.

K 1113

NEW KIT! $24.95

K 1115

NEW KIT! $34.95

'Follow Me' Robot Kit

Uses four inbuilt microphones to detect sound (such as a hand clap) and moves toward it. Ages 8+. No soldering required. Requires 4 x AAA batteries (not included).

K 1107

SAVE 27% $55

Robotic Arm & Claw Kit

A great introduction to basic robotics - ideal project for students. Includes five motors allowing base rotation, shoulder, elbow and wrist motion, plus claw for picking up objects (up to 100g). Includes wired controller.

K 1122

NEW KIT! $24.95

Salt Water Powered Buggy Kit

A V8 powered buggy that runs on salt water! No batteries required. This kit features a detailed engine with moving cylinders and crank shaft. Ages 8 and up.

K 1116

NEW KIT! $15.95

Salt Water Crawling Spider Kit

This creepy crawly spider uses a salt water reactive fuel cell to power its legs. Just by adding some salt water to the cell plate, the spider will creep around. No batteries required! Ages 8 and up.

K 4030

NEW KIT! $54.95

High Energy Ignition Kit

(SC November '12) Revised design for 2013 - cheaper too! Use it to replace a failed ignition module in an older car or upgrade a mechanical ignition system when restoring a vehicle. It will work with virtually any ignition system that uses a single coil.

NEW KIT! $29.95

K 6047

Mains Timer Kit For Fans & Lights.

(SC August '12) This small module can save power by switching off fans or lighting after a period between 5s and 1 hour. It can also be hooked up to a mains rated push button for a timed manual activation. 5A/1250VA max rating. Note: must be installed by a licenced electrician in most states.

K 5804

NEW KIT! $89.95

LED Musicolour Kit

(SC October '12) Updated Musicolour for LED technology! A continuously changing kaleidoscope of colour changing in time to the music. Controls up to 16 strings of LEDs tuned to individual frequency bands. Great for Christmas lighting or DJ's and parties.

NEW KIT! $69.95

K 5181

'Classic-D' Amplifier Module Kit

(SC November '12) A rugged and reliable Class-D audio amplifier producing up to 250W into 4Ω. This high efficiency, high power design is ideal for building into any audio amplifier design. Class-D amps are commonplace amongst consumer equipment. Low distortion <0.01%. Based on the IRS2092 audio amplifier chip.

K 2553

SAVE $20 $129

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(SC March '10). With S/PDIF coaxial and optical output - plus dual analog outputs! Incredibly low distortion (typically <0.06%). Sine, square, triangle and sawtooth wave generator. Plus waveform mixing, pulse and sweep modes. Ideal for RMS and music power testing of amps or speakers; testing DACs & crossovers. Requires 4xAA or 9V plugpack

K 4500

NEW KIT! $54.95

Dog Blaster Kit

Keeps your woofer quiet!

(SC August '12) Are barking dogs keeping you up to all hours? The dog blaster hooks up to high power piezo tweeters (not supplied) and outputs an ultra high frequency sound to deter dogs from barking constantly. Note: Please use responsibly. Excessive use may actually make barking worse if the dog gets used to the noise.

K 5182 Optional speaker protector $19.95

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What do you do when you have stuff left over from another project? You think of uses for it, of course! Here we make some surplus halogen down-light transformers the heart of a simple car battery charger.

Rugged Battery Charger from Bits 'N' Pieces

By Ross Tester

Readers will recall the feature in February this year where we replaced some power-hungry 12V halogen down-lights in our office with much more efficient and brighter LED fittings from Tenrod. We're absolutely delighted with the result (you will be too if you follow our lead).

But then we started thinking what we could do with the now-surplus 12VAC transformers and sundry light fittings/globes.

The light fittings and holders were consigned to the "round file" – they were discoloured with age, the wiring was brittle and we certainly didn't want to put in any more halogen down-lights (that was the point of the exercise, after all). But at least the transformers were functional and it seemed such a shame to bin them. What could we do with them?

We quickly came up with a number of ideas and this is the first: a basic car battery charger that can put out a good 10A or so, with three of these trannys in parallel.

Commercial chargers with this rating are expensive so if we could cobble up a cheap equivalent, so much the better.

We're assuming that the transformers you remove are iron-cored and not the so-called electronic type. "Electronic" transformers cannot be used for our purpose.

Typically the iron-cored transformers are labelled 4A (or close to it) and 11.4-11.6VAC. That means they're intended for 12V 50W halogen down-lights.

If you're removing them all from one area, the chances are they will be identical.

This is quite important as far as this project is concerned – you should not mix'n'match brands otherwise one of them may tend to take the lion's share of the load.

If your transformers are identical in brand and style, the chances are also good that they were installed at the same time and are all part of the same batch, wound on the same machine, so the output voltages should be the same. You can check this out before use with a DMM if you wish – ours were within a couple of millivolts of each other.

We're using three transformers in parallel which gives us a nominal output of just on 12A (ie, 3 x 3.95A).

You won't quite get that much (we'll explain why shortly) but as we mentioned earlier, it should be good for 10A or so. If you only need (say) 6A or so, or if you only have two identical transformers, go right ahead.

Using identical transformers in parallel is not too dissimilar to paralleling windings on the one transformer to give higher current.

For example, you might have a transformer which has two separate secondary windings rated at 6V, 1A – you can connect these (in the right phase) in series to give 12V @ 1A or in parallel to give 6V @ 2A. That is effectively what we are doing here.

It's not *quite* according to Hoyle but we've done it before and it works.

Again, though, we must emphasise that they must be identical transformers – and definitely not electronic versions!

What else do you need?

Basically, all you need is a hefty bridge rectifier to convert the AC output of the transformers to unsmoothed DC, to charge a battery.

Naturally, you're also going to need hardware to safely connect the transformer primaries together (and thence to the mains) plus connections from the secondaries to the bridge rectifier and thence output cables for connection to the battery to be charged.

Add a case to put it all in and Bob's your uncle.

Well, nearly so. It will also need a mains cable, mains switch and fuse.

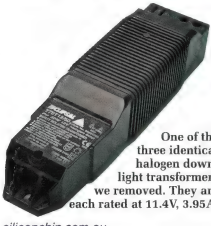
We elected to use an IEC mains socket with integrated fuseholder – saves having a mains lead dangling out the back to get damaged and we also have plenty of IEC mains cords left over from other devices – you probably have a few as well.

You can get an IEC mains (male) socket with both integrated fuseholder AND mains switch but we didn't want the mains switch on the back of the case, so elected to use a separate switch up front.

And because it's now getting rather difficult to buy a round-hole-mounting mains switch with an integrated neon indicator, we added a separate neon bezel.

The case

This presented something of a prob-



One of the three identical halogen downlight transformers we removed. They are each rated at 11.4V, 3.95A.

The Supercheap Auto Storage Box. Remove the seven plastic trays and presto! A case complete with handle!

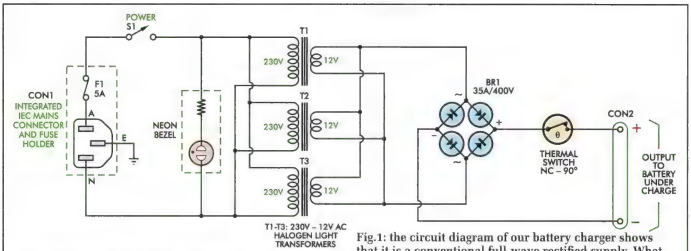


Fig.1: the circuit diagram of our battery charger shows that it is a conventional full-wave rectified supply. What is not conventional is driving the bridge rectifier with three transformers in a parallel. It's not strictly-speaking according to the rule book – but we've proved that it works!

SC BITS'N'PIECES BATTERY CHARGER

lem. We wanted a metal case, preferably steel, to house the charger but once again, suitable cases are starting to become as rare as the proverbial.

And those that are available are worth a fortune – definitely not what we wanted for a "surplus parts" project.

So instead of a purpose-made case, we purchased a steel storage box from Supercheap Auto for less than $20. It's called an "SCA Multistorage Case, 7 Compartment".

It's more than strong enough, about the right size and it has a couple of nice features such as a carry handle and provision for semi-permanent locking.

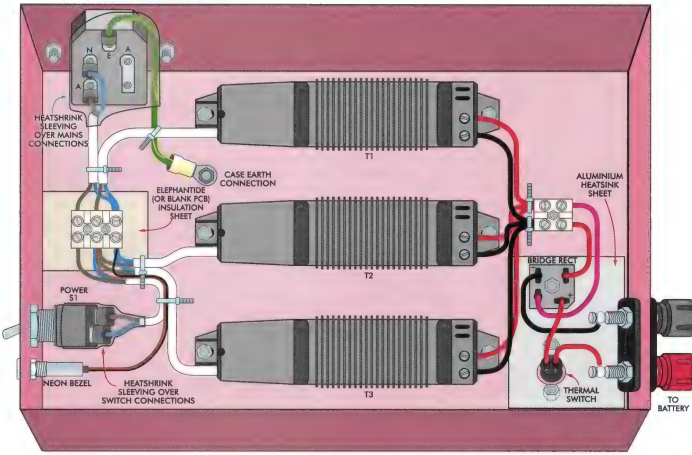
If you're not in a hurry, Supercheap Auto regularly have "20% off everything sales" so it could be yours for even less.

But if you happen to have a suitable case on hand, so much the better.

Output leads

We could have made up a set of charger leads from heavy-duty cable and large alligator clips but "why reinvent wheels?". Cheap jumper leads already have the heavy-duty cable and large alligator clips – all we had to do was remove the clips from one end.

We've seen these before in bargain



stores for less than $10 but of course, when we went to get them there weren't any.

Supercheap Auto had some but they weren't super cheap. However, we managed to get a set from Repco for less than $20.

You may even have a surplus set of leads that you can sacrifice for this project – they don't have to be super-high current leads.

If you have to buy some, get the cheapest you can find. Normally, we'd never recommend these – as jumper leads they make great shoelaces but for our purpose, they're more than adequate.

By the way, most jumper leads have rather extravagant claims for current rating – like 400A and so on. But if you look at the leads closely, you'll see that they are probably about 80% insulation and 20% (or less) wire.

Given the fact that they are intended for 12V (or perhaps 24V) usage, we wonder why they need insulation rated at, what, kilovolts and grossly exaggerated wire "capacity"? Hmm!

What else did we use?

The main item is the rectifier – we used a metal 35A/400V bridge (Jaycar ZR-1324 @ $4.95). We don't need either the 35A or 400V ratings but they give a nice margin for safety.

Following this is a normally closed (NC) 90° thermal cutout (Jaycar ST-3825 @ $5.75) to protect against shorting the output leads.

At the same time, we also grabbed a strip of 12-way ultra-large terminal strip (HM-3198 @ $2.95) and a couple of metres of 25A hookup wire (WH-3080/3082 @ $2.20/m).

Finally, we wanted some large output terminals and Jaycar had a polarised heavy-duty pair (PT-0457 @ $6.95).

We could have saved this cost by bringing the charger leads out through a gland but again, we didn't want to have leads permanently hanging from the case.

Apart from nuts and bolts to mount everything (see parts list), rubber feet, some heatshrink tubing and scraps of thick aluminium (to act as a heatsink) and PCB material (for an insulator), that was it.

The cost

OK, so if you have to buy everything (except the transformers!) it all adds up to $60-ish but we couldn't find a charger of this power for under $100.

If you have a lot of what's needed in your junk box – and many hobbyists will – the cost will obviously come down.

How it works

See the circuit of Fig.1. This one is definitely not rocket science! It's a typical full-wave rectified supply producing pulsating DC at the output.

What's not typical is that we've used three transformers, all wired in parallel so all contribute their share of the nominal 12VAC @ 12A output to the bridge rectifier.

(We mentioned earlier that the transformers are labelled 11.4V but this would be at the full 3.95A output. Unloaded or not fully loaded, the voltage is at least 12V, perhaps a bit more).

Once rectified, the pulsating DC voltage will be 12 x 1.4142 or 17V, less the voltage drop across the two diodes in the bridge rectifier conducting at the time (2 x 0.6 or 1.2V) = 15.8V. This is the peak voltage.

Because it is unsmoothed (ie, pulsating) DC, the voltage you read with your multimeter will be less than this, actually peak x 0.707. So the output should measure around 15.8 x 0.707 or

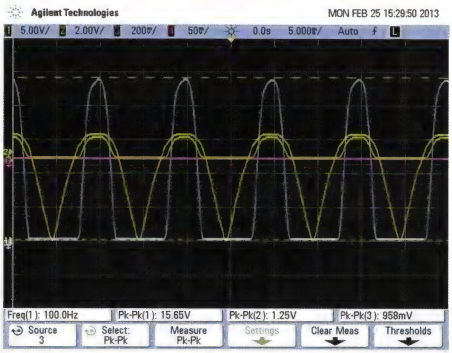
This set of four scope wave-forms demonstrates the operation of this car battery charger.

The yellow trace shows the unsmoothed DC output of the battery charger with no battery connected but with a load of 1kΩ (to give a clean waveform).

The green trace shows the output of the battery charger when connected to a battery which is being charged at about 3A. The humps in the green waveform occur each time the battery gets a pulse of current (ie, 100 times a second or 100Hz).

The flat portions of the green trace represent the battery voltage at times between each current pulse while the pink trace (partly obscured by the green trace) represents the battery voltage when charger is turned off. Naturally the average voltage when it is being charged will be slightly higher than when the charger is turned off. Hence the green trace is slightly above the pink trace.

The peaks of the yellow trace are slightly above the peaks of the green trace (battery voltage under charge). This is to be expected because the battery places a considerable load on the charger output.



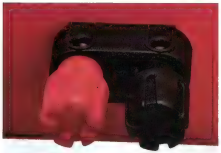
The blue trace shows the amplitude of the 100Hz current pulses being fed the battery. It represents the voltage across a 0.1Ω resistor in series with negative lead from the battery charger and has a peak-to-peak voltage of 958mV (across 0.1Ω). This means that the current pulses are peaking at 9.58A; much higher than might be thought with an average current of about 3A.

Note that the maximum current delivered by the charger will depend on both the mains voltage at your location and the state of the battery being charged.

11.17V. But aren't we trying to charge a 12V battery? How can we do this if the output voltage is less than the nominal battery voltage?

The reason is that current flows into the battery whenever the peak voltage exceeds the battery's nominal voltage. Remember a moment ago we said that the peak voltage was about 15.8V?. So when the charger voltage rises above 12V (or whatever the battery voltage is at the time) current will flow into the battery, charging it.

And this happens 100 times every second as the pulsating DC voltage starts at zero, rises up to 15.8V then falls to zero again. See the scope grab above.



The twin output terminals (binding posts) we used – these have large holes which easily fit the jumper lead cables. Some binding posts can be a real pain to connect to!

How much current?

We mentioned earlier that you wouldn't expect to get the full 12A from three 4A transformers. There are

We chose an IEC socket with integral fuseholder (at the bottom) – it means the fuse is before the mains switch but this isn't a great problem.

The latches on this case have a screw hole right through them which means you can semi-permanently lock the case. (See screw & nut at bottom of latch). That's important if there are young hands around . . .

losses in the system – for example, the voltage losses in the rectifier and also due to the resistance of the wiring and leads.

But we'd be surprised if you didn't get at least 10A peak into a "flat" battery as ours did. This reduces, of course, as the battery charges.

The one big disadvantage of a simple battery charger like this is that it will continue to try to "charge" the battery, even though the battery is nominally "charged".

So beware of this – if the battery fluid starts to bubble (gas), turn off the charger and disconnect it (not the other way around – that bubbling is hydrogen gas and you really don't want to have any sparks around that!).

Construction

When you open the SCA case, you'll find there are seven plastic compartments inside. You don't need them for this project (in fact, they won't fit!) but they make dandy little parts holders for your workbench!

Layout within the case is not critical but the main thing to remember is that this is a mains device – care must be taken with the mains wiring and the output wiring must be kept completely separated from the mains, with no possibility of connection should a wire work its way loose.

One advantage of the transformers we used is that they have nice, big holes for cable connection – even the 25A auto cable fits easily.

We marked all hole positions before drilling any. That way you can easily move something if necessary!

Start by placing the transformers in the case. If you're using three, as we did, it makes sense to locate one right in the middle (ie, on the centreline) and the others lined up, about 10mm in from the edge of the case.

When you're happy with their positions, mark their screw hole positions with a fine felt pen.

The two lengths of terminal strip (one 3-way, one 2-way) also sit on the centreline. The 3-way length, the one that connects mains power, has two screws holding it in while the 2-way obviously can have only one screw.

At the "mains" end, you'll need to mark a hole position for the earth screw. We positioned the mains switch and neon on the end of the case, equal distance from top and bottom. The bezel (7mm hole) is 25mm in from the front and the mains switch (12mm hole) another 20mm further in.

The only other hole in this end of the case is the cutout on the rear for the fused IEC socket. Mark its position and cutout carefully – there's not a great deal of "meat" on the edges of the socket. The cutout can be made by either drilling a series of small holes and finishing off with a file, or using a nibbler. Note that there are two chamfered corners on the bottom of the cutout.

At the opposite (output) end in the bottom of the case there are holes required for the 2-way terminal strip mentioned above and the bridge rectifier and thermal cutout. We mounted the two latter components on a small piece of thick aluminium to act as a heatsink, with screws going through both the case and heatsink. We worked out the positions of both components on the heatsink then used that as a template to drill the holes through the case.

The pair of output binding posts needs careful drilling to ensure it fits and sits correctly – it has two 10mm holes 19mm apart. Again, this socket was mounted at the midline of the side of the case, the first hole 25mm from the front edge and the second (obviously!) 19mm further in.

We used M4 screws for the transformers, earthing point and bridge rectifier; M3 for the rest. You will need to remove paint around the earthing point so that the screw is guaranteed to contact bare metal. This screw needs to have, from the case up, a star washer, nut, crimped earth wire lug, shakeproof washer and finally another nut to ensure the earth wire is held securely in place.

Because there are screwheads emerging from the bottom of the case, it makes sense to place some rubber feet on the underside – because the chances are someone will "rest" it on a car bonnet. Self-adhesive feet are easiest – you don't need to drill any holes.

Parts list – Rugged Battery Charger

3 (or 1 or 2 – see text) 230V to "12V" @ ~4A downlight transformers, same brand & type (not electronic type)
1 suitable steel or aluminium case, approx. 330 x 225 x 68mm (eg, "SCA" brand multistorage 7-compartment carry case from Supercheap Auto, $19.95)
1 IEC male chassis connector with integral fuse holder and 5A fuse
1 SPST mains switch
1 Neon bezel (230V)
1 BR354 (or similar) 35A/400V bridge rectifier
1 90°C thermal switch, normally closed
2 large red & black terminals (binding posts)
1 12-way large terminal block (eg Jaycar HM3198)
1 earth lug crimp terminal
1m 25A Auto cable – red and black
1m twin-core mains cable
1 set economy jumper leads
heatshrink to cover mains socket and switch, all exposed terminals
5 M3 x 10mm screws with nuts & washers
3 M3 x 20mm screws with nuts & washers
8 M4 x 10mm screws with nuts & washers
1 M3 x 30mm screw with nut & washer
4 rubber feet, self-adhesive
1 aluminium offcut for heatsink, roughly 100 x 60mm
1 blank PCB or plastic offcut for mains terminal block insulator, roughly 50 x 50mm
Small cable ties

Connecting it up

Once all the holes are drilled/cut, it's quite a simple matter to connect it all together using our photos and diagrams as a guide.

Ideally, we would have used spade (quick-connect) connectors to attach to the various terminals but there are two problems here – the different sizes of lugs (I think there are five!) and second, the thickness of the wire on the secondary side makes getting the connectors on and crimped a bit of a chore. OK, there was a third problem – I forgot to buy any!

So I elected to solder all connections. Just make sure before you solder the wires make a good mechanical con-

nection (ie, they won't pop off even without solder).

Pre-tinning any connectors also makes sense because it's sometimes difficult to solder thick wire – it really sucks the heat away from the iron. With pre-tinning you have a much better chance for a really good solder joint.

The connections between the transformers and bridge rate special mention. We already said that we obtained some thick (ie, high current) wire for these but we haven't mentioned they should all be cut to *exactly* the same length. This is to ensure, as far as possible, that the load is shared between the transformers – even a few milliohms of difference could matter.

We used red and black wire simply because we had some and that made the phasing of the transformers easy – it's essential that the three (or even two) transformer outputs are connected in phase, otherwise they will see a short circuit in each other.

Ideally, you should check that the outputs are in phase by comparing the waveforms on a 'scope. But if you don't have one, don't worry too much – again, with three identical transformers you'd expect the terminals to be connected the same way.

Now you'll find out why we used an ultra-large terminal strip – you need to connect the three wires together and anything smaller simply won't have room to fit them in. As it is, they're a tight fit – but they do. Fit, that is!

We've only run one length of wire from the terminal strip to each of the bridge terminals – we would have liked to use a larger cable but didn't have any.

Again, wrap the bare wire around the bridge terminals before soldering – that's after you take note which terminals are which. One of the AC (input) terminals is always identified, as is the + terminal. The diagonally opposite terminals are the other AC input and the – terminal, respectively.

A thick black wire connects directly from the – bridge terminal to the black output terminal, while a thick red wire connects from the bridge + terminal to the thermal cutout, with the same from the thermal cutout to the red output terminal.

We covered all exposed terminals (ie, on the IEC socket and the switch) with heatshrink tubing and shrunk it to fit when finished. The same treatment was given to all soldered connections on the output side – the bridge rectifier, the thermal cutout and the output terminals.

And finally, we used a few small cable ties to bundle the wires together.

All closed up and ready to go. You've even got a handy carry handle to handily carry your charger to where it's needed!

Is it finished?

Once you've checked all your wiring – and especially checked that no strands of wire poke out from your terminal strips – you can test that it works.

Don't connect any output leads yet but connect a, say, 1kΩ resistor (any wattage) across the output terminals to give the rectifier a small load (that's all it needs at the moment).

Plug in power and turn it on. The neon should glow, telling you that so far all is well.

Measure the AC voltage at the terminal strip where the three transformer leads join. It should read just on or over 12VAC. Measure the DC voltage at the output terminals and it should be something similar – perhaps 11.5V (again, if you're wondering why, read the explanation earlier on).

Turn it off, remove the resistor and connect your output leads. While monitoring a 12V car battery voltage, connect the clips to the battery and turn it on again.

Unless your battery is fully charged, you should find the voltage rises a little and keeps rising. You should also find that the voltage is somewhat higher than your previous check without the output leads because the battery acts like a giant capacitor or reservoir, smoothing out the peaks of the waveform and thus increasing the average voltage.

Leave the charger on for, say, half an hour or so and check the temperature of the transformers. They will probably be quite warm but not excessively hot (they get pretty hot to the touch when operating in your ceiling!). Likewise the bridge rectifier. If that gets too hot, the thermal cutout will trip and cut power to the output.

Closing 'er up

If you're happy that everything works as it should, close the case up and snap the locks closed.

If you look closely at the bottom of the locks, you'll note that there is provision for inserting a 3mm screw (with nut), about 30mm long, through the whole thing, which stops the locks being opened. We'd be inclined to do this – despite covering all the bitey bits with heatshrink, you don't want anyone's fingers (especially little ones!) inside the case.

What's the charging current?

Next month, we'll show you how to add both a digital ammeter and a digital voltmeter so you know exactly what's going on.

Having set out to produce a low-cost, surplus parts battery charger this could be regarded as "gilding the lily" somewhat!

They do add to the cost of the project but also add significantly to the value and we think both are worthwhile additions (of course, you could choose to add only one meter instead of two – and/or leave it as is!).

An alternative would be to use a couple of dirt-cheap digital multimeters. Jaycar's QM-1502 DMMs are just $4.95 each – even cheaper than panel meters! SC

This low-cost arbitrary signal generator is compact and easy to use. It has outputs for two independently configurable waveforms, including sine, square, triangle, pulse, noise or just about anything you can come up with, at frequencies up to 50MHz. It can also be used as a frequency counter.

THE SIGLENT SDG1050 is a low-cost 50MHz arbitrary function generator. It is a compact instrument (229 x 105 x 281mm) which has all the usual features that you would expect in this type of device.

Its manufacturer, Siglent, is the largest oscilloscope manufacturer in the world. Haven't heard of them? That's OK; neither had we. Their name isn't well known because they are an original equipment manufacturer (OEM) and most of their scopes are sold under other brands. Siglent and a couple of other Chinese manufacturers make most of the entry-level scopes for name brands.

So they obviously know how to make test gear and that is confirmed as soon as you open up the box; the build quality of the SDG1050 is top notch and it feels solid and well-made.

There are some nice design touches; for example, the bail doubles as a carrying handle and the stand has indentations for your fingers which give a reliable grip for carrying the instrument. And there are rubber "feet" on all the corners as well as plastic feet on the back, so you can stand the instrument in just about any orientation without damaging it or the surface it's on.

They've also included a great bonus feature; if you aren't using the trigger input, you can also use the unit as a frequency counter which can operate in the range of 0.1Hz-200MHz. This is accessed through the on-screen "utility" menu and you get a few options such as whether to measure frequency, period, pulse width or duty cycle, what the reference level is for counting pulses, whether it is AC-coupled and also optionally enable a low-pass filter.

Signal generators

In addition to arbitrary waveform shapes that you can define on one or two channels, it has various built-in waveform shapes such as sine, trian-

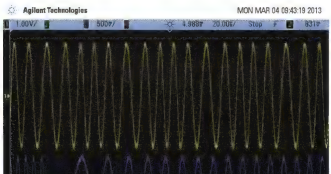


Fig.1: the output of the SDG1050's two outputs showing how they can be used independently. Channel 1 (yellow, at top) is producing a 100kHz sinewave which is being frequency modulated with another sinewave with a longer period. At the same time, channel 2 is performing a sweep.

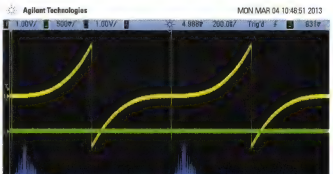


Fig.2 this shows two of the built-in arbitrary waveforms that you can select. The yellow trace at top is generating an x^3 function at 1kHz while the other channel in blue is producing the "earthquake" function at the same frequency. The sync output has been enabled and the pulses from this are shown in green.

gle, sawtooth, square and white noise. It can generate signals with amplitudes from 4mV peak-to-peak up to 20V peak-to-peak into a high impedance load or half that into 50Ω. Channel 2 is limited to 6V peak-to-peak or 3V for 50Ω.

The signals can be swept, output in bursts or modulated using AM/FM/PM/ASK/FSK/PWM. The modulation source can be an external analog signal or it can be an internally generated waveform of just about any type the unit supports. The sampling rate of the unit we are reviewing is 125MS/s and the voltage resolution is 14 bits. Maximum arbitrary waveform length is 16,000 samples or 256k samples if you disable one channel.

As well as defining your own waveform, there are 48 common types built in such as cardiac, exponential rise or fall, Gaussian, various FFT window shapes, x^2, x^3 and so on.

Maximum signal frequency is as follows: 50MHz for sine, 25MHz for square, 5MHz for arbitrary/pulse and 300kHz for triangle/sawtooth/ramp. To use the trigger output, signal frequency must be no more than 2MHz. Because the output is DC-coupled, very low frequency signals are possible, down to 1μHz in most modes. That also means an adjustable DC offset can be applied to the output.

The two outputs are totally independent and can be set up in any way that you like. It's possible, however, to copy the settings from one output to another if you want to set them up similarly. As you would expect of such a device these days, it has USB support. That includes both a host port to which a flash drive can be connected to save and load settings and waveforms and a device port (on the rear panel) which can be used to connect the unit to a computer for control.

For direct control, the device has a 9cm (3.5-inch) colour LCD, five "soft buttons" next to the display, a numeric keypad, rotary encoder knob/pushbutton, arrow keys and a number of mode pushbuttons, many of which are illuminated when that mode is selected.

The two output BNC sockets are on the front, adjacent to pushbuttons which can be used to quickly enable or disable that output. Besides the USB host port, all the other sockets are on the back and that includes four BNC sockets: the trigger output, trigger input, 10MHz reference clock input/output and external modulation input. There is also an earth point, the IEC mains power socket and the aforementioned USB device port.

Interface

So those are the specs but is it easy to use? Well, we found the interface a bit confusing when we first had a go at it (not bothering to read the user manual as usual) but very quickly figured it out. Most functions are controlled through a combination of the soft buttons (to select items from the on-screen menu), the mode buttons and the numeric keypad.

Say you want to generate a 1MHz sinewave with 50kHz frequency modulation by a triangle wave of 1kHz and generate a sync output. The procedure is as follows:

(1) Press the CH1/2 button to select the desired output channel;
(2) Press the sine button;
(3) Press the "1" button on the keypad, then the soft button labelled "MHz";
(4) Press the "Mod" (modulation) button;
(5) Press the "Shape" soft button until it reads "Triangle";
(6) Press the "Type" soft button until it reads "FM";
(7) Press the "1" button on the keypad,

then the soft button labelled "kHz";
(8) Press the "FM Dev" soft button, then type "50" and press the soft button labelled "kHz";
(9) Press the "Utility" button, then the "Output Setup" soft button;
(10) Press the "Sync" soft button, then "State" until it shows "On", then "Done".

That's all quite easy and most jobs are similarly straightforward once you've played with it for a few minutes. The interface therefore gets a thumbs up.

What we did find a bit odd though is that sometimes a menu pops up which prompts you to select from a list of options and you can then use the rotary knob to select one. But then if you press the knob in, nothing happens. You have to use a soft button labelled "Select" to make the selection when the knob pushbutton would have been more convenient. But that's a minor criticism.

PC software

Windows software called "EasyWave" is supplied to edit arbitrary waveforms which can then be loaded onto the signal generator. These can be hand-drawn point-by-point or can be based on mathematical functions, including trigonometric, exponential and logarithmic functions. They can be transferred directly using the supplied USB cable or via a flash drive.

Performance

So how does it stack up? In fact, it performs similarly to other arbitrary waveform generators with this type of frequency range and capability. Sinewave THD+N at 1kHz is around 0.05% (20kHz bandwidth) and doesn't vary a great deal with level although it does climb at very low output levels, to around 0.5% at 4mV peak-to-peak – quite impressive given how little signal there is at this output amplitude.

The signal-to-noise ratio is 96dB at maximum output level (20V peak-to-peak) and drops at lower output levels, as you would expect. That's if you switch between outputting a signal and DC. There's an extra 10dB of SNR if you switch the output off entirely.

As for square-wave performance, there is a little visible overshoot at 1MHz but the output is still basically square. By 10MHz there is some apparent rounding and at 25MHz it is somewhat trapezoidal. That's pretty much to be expected for an instrument with an analog bandwidth of 50MHz.

Voltage accuracy is good if you set the load impedance correctly; with the output set to 4V in high-impedance mode, our scope gave us a reading of 4V while a true RMS multimeter gave 3.99V; pretty much spot on.

Frequency accuracy is specified as ±100ppm, ie, ±0.01% within the first year when operating with an ambient temperature of between 18-28°C. That means it makes quite a reasonable frequency reference too. If that isn't good enough, you can simply feed in a more accurate 10MHz reference clock from another piece of equipment.

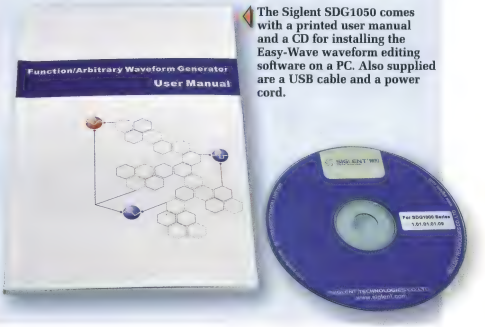
Conclusion

The Siglent SDG1050 does what it says; it's a capable dual-channel arbitrary function generator with decent performance and good build quality. It costs $595 + GST and is available from Trio Smartcal.

For further information, visit **www.triosmartcal.com.au** or phone them at 1300 853 407. You can also e-mail **sales@triosmartcal.com.au** for more information or to make a purchase.

Trio have some other options too, such as the 25MHz SDG1025 which has quite similar features to the 1050 (but 20MHz analog bandwidth) for $439 + GST. The more capable 80MHz SDG5082 is $795 + GST. These are all competitive offerings from Siglent and we have no hesitation in recommending them. SC

The rear panel carries four BNC sockets for the trigger output, trigger/frequency counter input, 10MHz reference clock input/output and external modulation input. There's also a USB device port (eg, to connect a PC to control the device), an earth point and an IEC mains socket.



The Siglent SDG1050 comes with a printed user manual and a CD for installing the Easy-Wave waveform editing software on a PC. Also supplied are a USB cable and a power cord.

Vintage Radio

By Ian Batty

The First "Trannie" – The Regency TR-1 4-transistor radio

The world's first commercial transistor radio, the Regency TR-1, was released in October 1954 (Photo: Steven Reyer).

In this world of smart phones, tablets and MP3 players, no-one carries a "tranny" any longer. But before we forget them completely, let's look back at the first of these pocket-size marvels, the Regency TR-1 4-transistor radio.

THE YEAR is 1953. Herbert Mataré, frustrated by the French Government's lack of support for his invention, the "Transistron", has left F. V. Westinghouse in Paris and moved to Dusseldorf, establishing Intermetall.

The transistor had arrived but not as many of us understand history. Matare had discovered the "transistor effect" independently of the famous trio of Bardeen, Brattain and Shockley. Yet, impressive as Matare's ground-breaking radio was, it used point-contact transistors, had no loudspeaker and was only a prototype.

The world would have to wait two more years for a commercial solid-state radio.

The first US transistor patents using semiconductors were issued to John Bardeen and Walter Brattain at Bell Laboratories in 1948. As a major US telecommunications company, Bell's primary intention was to use transistors as solid-state switches in exchanges, so portable radios were not a concern. The only other intended uses were hearing aids, computers and military applications. Bell did, however, demonstrate "a transistor-powered radio" at their major press announcement of the transistor's invention on June 30, 1948.

Added to this, Bell's efforts were directed at point-contact technology, for which they held the patent. By the beginning of the 1950s, it was obvious that point-contact technology was too unreliable and costly for mass-

production. By this time, the original Bell team of Bardeen, Brattain and Shockley had broken up.

Shockley, realising the limitations of point-contact designs and resentful of his name being omitted from the patent application, had subsequently independently invented the junction transistor. He went on to share the 1956 Nobel Prize for Physics.

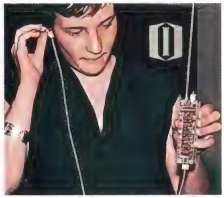
Shockley left Bell and, with funding from friend Arnold Beckman, started Shockley Semiconductor Laboratories in 1955, recruiting the best and brightest engineers and scientists he could find. However, Shockley's management style and inability to understand commercial imperatives resulted in failure to ship even a single commercial product and led to the mass exodus of the "Fairchild Eight".

Back in 1952, prior to the breakup of the Bardeen-Brattain-Shockley team, Bell Labs' Jack Morton had realised that Bell alone didn't have the resources to bring transistors into widespread commercial use. As a result, he arranged three famous seminars in that year, the first being for the US and NATO militaries while the second seminar was attended by industry giants and small innovators alike. Among the latter at this April 1952 seminar were Texas Instruments (TI) and Tokyo Tsushin Kogyo ("Totsuko"), later to become technology giant Sony.

Pocket transistor radio

TI's Mark Shepherd was convinced that a pocket transistor radio was possible. TI had begun making transistors for hearing aids and for the military but these were not major earners. In 1954, TI manager Pat Haggerty signed an agreement with the Regency Division of Industrial Development Engineering Associates, an Indiana company involved in making TV antenna boosters. The aim was that the two companies would work together to manufacture and market the world's first commercial transistor radio. That's if Ibuka and Morita didn't beat them to it!

Totsuko's Masaru Ibuka and Akio Morita clearly saw the potential of the transistor. Working among the ruins of postwar Tokyo, they had started out by making a humble rice cooker and a shortwave converter. They had then successfully progressed to designing, manufacturing and selling high-quality tape recorders for use in radio stations and courtrooms.



This tiny battery-operated transistor radio was demonstrated at the Dusseldorf Radio Fair in 1953 but never made it into production.

At the time, TI's own laboratories, as basic as they were, would have seemed palatial to Ibuka and Morita. Nonetheless, we now know that Regency's release of the TR-1 in October 1954 beat Sony to market by just a few months. Morita visited the US in March 1955, offering their TR-55 to the market.

The Regency TR-1: a first look

The first junction transistors proved far more reliable and stable than the earlier point-contact types. They were also easier to manufacture and far less noisy.

Nevertheless, the "grown-junction" design relied on exacting manufacturing techniques and the devices struggled to operate at radio frequencies much above 1MHz. Internal collector-base capacitance reduced the performance and created feedback that could easily turn otherwise acceptable amplifiers into useless oscillators.

The solution was to run the transistors at their maximum permissible voltages, thereby reducing capacitance. As a result, the TR-1 used a 22.5V "hearing aid" battery to ensure good performance.

Fig.1 shows the circuit details of the TR-1. It's a simple 4-transistor superhet design with conventional RF and IF stages, ie, a single-transistor "autodyne" converter, two stages of IF (intermediate frequency) amplification, a diode detector and AGC (automatic gain control).

The IF, however, is only 262kHz, a value also used in some US car radios. This compromise was forced by the limited high-frequency performance of TI's grown-junction transistors.

The audio section is less familiar and uses a single transistor operat-

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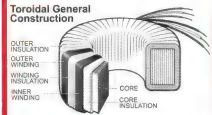

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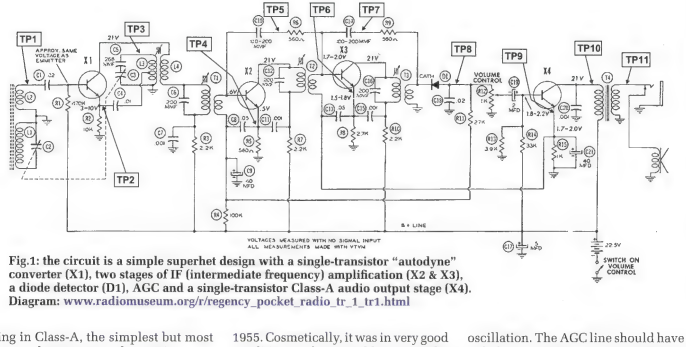


Fig.1: the circuit is a simple superhet design with a single-transistor "autodyne" converter (X1), two stages of IF (intermediate frequency) amplification (X2 & X3), a diode detector (D1), AGC and a single-transistor Class-A audio output stage (X4). Diagram: www.radiomuseum.org/r/regency_pocket_radio_tr_1_tr1.html

ing in Class-A, the simplest but most power-hungry type of operation.

An interesting and somewhat unexpected aspect of the design is that it used NPN germanium transistors. Most of the germanium transistors manufactured at that time were PNP types.

The use of only four transistors was an economic decision, since they wanted to sell the radio for just $49.95. The TR-1 prototype used eight transistors, ie, in the mixer, oscillator, two IFs, detector, audio driver and a push-pull audio output stage. However, with each transistor costing around $2.50, this would not have permitted the magical $49.95 price point.

As a result, the engineers took a "man overboard" approach. The mixer/oscillator combination became a single-transistor converter (US Patent 2880312) the transistor detector became a diode, and the 3-transistor audio section (with Class-B push-pull output) became a single-transistor Class-A stage.

Raytheon's competing 8TP, released some months later in March 1955, had eight transistors and sold for $79.95. That was over half as much again as the cost of the TR-1 and the equivalent of around $683 today. By contrast, the TR-1 cost about $426 in today's dollars. It's rather ironic that Raytheon's 8TP is similar to the original TR-1 design.

The author's TR-1

I bought my TR-1 (serial number 47,939) online for $200. The "506" date-stamp on the tuning gang shows that it was made in the sixth week of 1955. Cosmetically, it was in very good condition, with acceptable wear on the case and no battery corrosion.

Unfortunately, when I tested it, it was dead. A few quick checks revealed oxidation on the on/off switch contacts and on the earphone socket. Once these were cleaned up, the set then responded weakly to my signal generator.

I then injected audio into the top of the volume control but it needed hundreds of millivolts to give even a weak output.

One of the main causes of faults in valve sets are defective paper and electrolytic capacitors. Transistor sets also suffer from faulty capacitors, mainly electrolytics that have "dried out" and gone almost open-circuit.

This set was no exception. Replacing the coupling capacitor (C19) in series with the volume control gave some improvement, while replacing the emitter bypass capacitor on transistor X4 gave a big improvement. It now took just 20mV in to give the full 6mW output at the onset of clipping.

With the audio amplifier stage sorted, I then found that the set burst into oscillation as a station was fully tuned in. At first, I suspected instability in the IF stages but the oscillation only happened with strong signals. Capacitor C9 (base circuit of transistor X2) was the culprit. It was open-circuit and was failing to bypass the detected audio signal on the AGC line to ground.

Allowing this detected audio back into the IF stages was the cause of the oscillation. The AGC line should have only been returning smoothed DC for gain control.

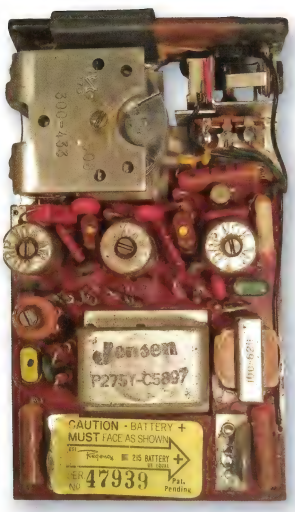
In the end, I "replaced" all the electrolytics by wiring new capacitors in parallel with the existing units. Fortunately, I was able to insert the new capacitors between the circuit board and the metal chassis, so the set still looks original. Of course, this approach would be impractical with any capacitors that had shorted rather than gone open circuit.

The RF "front end" turned out to be operational, although the set's performance was still a bit below par. Subsequent testing showed the IF alignment to be unsatisfactory.

Fortunately, the oscillator coil and IF transformer cores were sealed with soft wax, rather than the dreaded plaster-like paint seen on so many sets. As a result, it was easy to make the necessary adjustments. As noted above, the IF should be 262kHz but on this set it was just a bit high, so it was adjusted down.

Sets with ferrite rod antennas commonly have no "low-end" aerial circuit tuning. With long ferrite rods, it's possible to slide the aerial coil along the rod to peak the performance at a specified frequency at the low end of the dial but the TR-1's coil was wax-sealed. Because of this, it's very tempting to simply adjust it at the specified 535kHz (as the Regency service manual advises) but this method does not always give the best results.

In the end, as a compromise, I sim-



These two photos show the author's fully-restored Regency TR1 transistor radio. This unit has a black case but grey, red and ivory were also initially available, with other colours added later.

ply tweaked the oscillator slug up and down, readjusting the generator each time, until I found a setting that gave maximum sensitivity – at almost exactly 540kHz.

Easy access

The set is designed with the solder side of the circuit board facing the metal chassis. As a result, most of the resistor ends are easily accessed and signal injection into various points on the circuit is also fairly easy.

For IF alignment, it's easy to connect TP3 to ground to kill the local oscillator (LO). That done, I found that signal injection into the first IF at TP5 worked fine but injecting into the second IF at TP7 occasionally provoked loud oscillation.

Signal injection to the audio stage can be either direct into the wiper of the volume pot or you can disconnect the lead from the detector and inject the signal directly into the top of the pot.

Table 1 shows the signal input levels at test points TP1, TP5 & TP8 for 3mW output with the volume control at maximum (about 0.23V across the speaker). The RF and IF signals were 30% modulated at 1 kHz, while the audio signal into TP8 was a 400Hz sinewave.

Battery

Transistor feedback capacitance (ie, collector-base capacitance) reduces with increased collector-base voltage. Conversely, this capacitance increases as the battery voltage falls.

As a result, one common cause of oscillation in this set is low battery voltage, ie, as the battery runs down. My set "takes off" below about 16V.

The original battery was a 22.5V No.215 hearing-aid battery which is still available online. Alternatively, if you have an old battery, you can remove the innards and fit two 12V A23 types (as commonly used in doorbell transmitters) inside the old casing.

If, like me, you'd rather not apply the full 24V to the set, it's fairly easy to pry open one end of the wrap-around metal case, remove one cell and re-crimp the end (Editor's note: this shouldn't be necessary as a 22.5V battery would have delivered around 24V when new). It's then just a matter of connecting the two batteries in series and stuffing them into the old battery's casing.

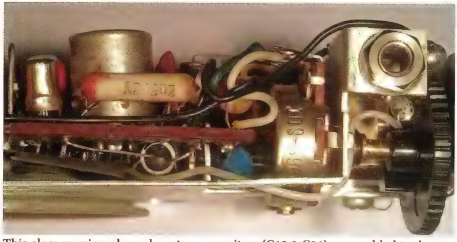
Table 1: Signal Levels For 3mW Output

TP1 (540kHz)	TP5	TP8
30μV	13mV	25mV

By the way, you can also do this for the 22.5V batteries used in AVO (and other) analog multimeters (the full 24V is just fine). I've also done this with replacements for the miniature 415-type 45V battery used in super-compact valve sets (four A23 12V batteries in series gives 48V).

How did they do it?

Although small, the TR-1 is not as compact as it might have been. Emerson Radio Corporation was already



This close-up view shows how two capacitors (C19 & C21) were added to the underside of the circuit board. The old capacitors were left in place on top of the circuit board to maintain the original appearance.

producing compact valve sets using sub-miniature valves, although these sets were somewhat larger than the TR-1. The TR-1 measures 35 x 125 x 76mm, whereas the 4-valve Emerson 747 measured 37 x 155 x 90mm.

Unlike Sony's preference for in-house components, Regency took the expedient approach of sourcing existing components. The TR-1 prototype even used a "salvaged" tuning-gang from an Emerson 747.

The only purpose-designed components were the ferrite rod, the oscillator coil and the three IF transformers. These new designs were necessary to match transistor circuit impedances, which are low in comparison to valves. In addition, IF transformer design was simplified and made more compact by using single tuned circuits, whereas most valve sets use two tuned circuits for each IF transformer.

The resistors and capacitors used in the set were types commonly available at the time.

The high collector-base capacitance of the transistors used isn't a problem in the converter and audio stages. However, the IF stages, just like the TRF valve sets of the 1920s, cannot operate successfully with significant internal capacitive feedback.

Just as TRF sets were rescued by the Hazeltine "Neutrodyne" patent, using carefully-adjusted feedback to neutralise anode-grid capacitance, Regency used controlled feedback to "unilateralise" their IF amplifiers. The relevant components are C10/R6 and C14/R9, with selected capacitors individually supplied with their companion transistors for assembly.

These RC networks are required since the feedback from the transistors isn't exactly 180° out of phase. This means that the neutralising network's feedback phase also needs to differ from the simple 180° specified in the Neutrodyne patents.

Minimising the current drain

In operation, the Regency TR-1 receiver draws around 4mA, giving about 20 hours of operation from a 22.5V hearing-aid battery.

To minimise current drain (and extend battery life), the bias divider usually required for the second IF stage was discarded. Instead, this stage derives its bias directly from the emitter of the audio output transistor (US Patent 2,892,931). This saves about 600μA of battery drain, a reduction of around 13%.

How good is it?

The TR-1's performance is mediocre, even by the standards of the early 1950s. In fact, the April and July 1955 issues of "Consumer Reports" separately put the TR-1 and Raytheon's 8-transistor 8TP to the test and concluded that Raytheon had every reason to call its 8TP the first serious transistor radio. The April 1955 review of the Regency TR-1 found the $49.95 TR-1 to be a toy-like novelty which didn't come at a toy-like price, and stated that "the consumer who has been waiting for transistor radios to appear would do well to await further developments before buying".

My own tests on the TR-1 were all done at 3mW output, at which point the second harmonic distortion was -20dB and the third harmonic distortion was about -13dB. The frequency response (at the speaker terminals) was -3dB at 270Hz and 2.3kHz, referenced to 1kHz.

The audio output is rather limited but the RF sensitivity is quite respectable at about 500μV/m at the bottom end and around 700μV/m at 1600kHz. Most sets, however, give better sensitivity at the top end and the difference can easily be a 3:1 improvement. In this case, the TR-1's lack of improvement at the top end indicates that the converter is working at the upper end of its frequency range.

Indeed, one milestone in the TR-1's development was when the converter proved capable of oscillating reliably up to about 1.9MHz, so that the receiver could reach the top of its intended tuning range.

The above figures may sound poor but it's not surprising considering that the design uses just four transistors. In fact, a 5-transistor Mullard design using the alloy-diffused OC169/170 transistors from the 1960s has only about 10 times better overall sensitivity than the TR-1, ie, about 50μV/m for 3mW output at 540kHz.

Ultimately, the signal-to-noise performance of any set is determined by the "front end", especially the mixer. That aside, the TR-1's performance is almost as good as most of my 6-transistor pocket radios.

An iconic design

The TR-1 is now lauded as an iconic design. Its release, along with the early transistor sets from other companies, firmly established solid-state technology as the future of electronics.

These days, you can buy a smart phone for less than the equivalent 1950s price of a TR-1. By contrast with the TR-1's four transistors, a smart phone has billions of transistors embedded in its internal microchips and, along with its phone functions, includes a camera, an audio player, a GPS and email and internet browsing capabilities – all accessible with the swipe of a finger across a touch-sensitive screen.

However, it probably won't let you listen to radio stations on the AM band and that's something the TR-1 can do!

For further information on the Regency TR-1 transistor radio, point your browser to **http://www.mequonsteve.com/regency/** SC

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Confusion about calcium batteries

I have just bought a new battery for my car and it is a lead/calcium no maintenance sealed battery. (Supercharge MF75D23L). A friend of mine advised that calcium batteries require a higher charge rate to enable the battery to reach full capacity. My car is a 2005 Nissan Maxima and I have measured the charging voltage after a long drive at 14.2V DC which to me is good.

On some websites, they talk about higher charge voltages up to as high as 15.1V DC for lead/calcium batteries. Other sites say that the battery manufacturers advise that lower charge voltages like 14.2V DC are OK. Battery manufacturers do not advise charge voltages, for example AC Delco and Supercharge **http://www.acdelco.com.au/PDFs/ACDelco_BatteryCharging-Guidelines.pdf**

Now I am aware that I cannot adjust the charging voltage in my car but after looking at various websites I have to say I am confused about the charging voltages required. I do not remember an article written on this and wonder if you can give some advice. (F. W., via email).

● Basically, calcium batteries are still lead-acid types. These batteries can accept a higher charge rate than standard lead-acid batteries but this higher rate is not a requirement to obtain full charge. The charge voltage is similar to standard lead-acid batteries although the calcium batteries can also accept a higher charge voltage.

In other words, the actual charge voltage is not as critical for calcium battery longevity as it is for a standard lead-acid battery.

Battery charging in a vehicle is never ideal anyway and the charge voltage is rarely correctly compensated for temperature. This means that a calcium battery with its wider charge voltage acceptance is better suited to use in vehicles.

Time out facility on RCD Tester

With respect to the RCD Tester featured in the Circuit Notebook pages of the March 2013 issue, does the RCD test time out and remove power from the 7.5kΩ 10W load resistor? I am concerned about possibly having that resistor energised at mains potential for longer than is necessary.

If not, is it possible to modify the circuit or software to provide that facility? Also, given that any test result of more than 300ms is a fail, can the LCD be made to indicate that? (S. G., via email).

● There is an inbuilt time-out feature that removes the input to the optocoupler, thereby disconnecting the earth leakage resistor in the event that the RCD fails to trip. This is covered in code lines 75 to 86. The LCD will display "– Fail" if the trip time is >300ms or 15 cycles and "– Pass" if less than those values. This is covered in code lines 232 to 258.

Questions about the SD card recorder

For more years than I care to remember I've fiddled with digital electronics but have now finally decided to have a go at analog electronics; well audio specifically. I have a few questions regarding the SD Card Music/Speech Recorder/Player from the August 2009 issue. I have no desire to carry 450-500

Using The Quick Brake Light Trigger On A Turbo Blow-Off Valve

I have a Quick Brake Light Trigger that was designed by John Clarke and first published in the March 2004 issue. After seeing this circuit featured in an article appearing in Autospeed (June 2004, Issue 286, **http://autospeed.com/cms/title_The-AllElectronic-BlowOff-Valve/A_2188/article.html**) about using it to trigger a turbo blow-off valve, I have built the system they featured to be used on a 2007 2.8L turbo diesel Jeep Cherokee to provide turbo surge protection.

The system has been assembled, tested and connected to the Jeep and senses the throttle lift-off just fine. Because this circuit is only being used in my application for triggering a solenoid valve to dump the surge on lift-off, I only want it to trigger on a significant lift-off that will create a compressor pressure wave and not just a back down.

So while it works very nicely, I would like the differentiator to be a little less sensitive. Putting it another way, I think that my issue may be with the RC time constant. Is there a way in which I can change the circuit to make it so only a more rapidly changing signal is allowed through? This is with VR1 fully turned clockwise to reduce sensitivity and no, the trimpot is not installed backwards. Any ideas? (G. D., via email).

● For it to operate at a faster rate of lift-off of throttle than available with the VR1 adjustment, reduce the value of the 100nF capacitor at pin 1 of IC1a. This capacitor is located just above pin 1 of IC1 on the PCB.

You should be able to change the sensitivity of the circuit to suit your purpose by using a 10nF capacitor instead. That will increase the adjustment range of VR1 so that when set fully clockwise, the required rate of change to trigger the switch is 10 times that of the original configuration.

The 10nF MKT polyester capacitor may have the code 103 or 10n written on its body rather than 10nF.

music CDs, 60kg of weight and space, in a caravan when I can use SD cards.

I cannot find any mention at all in the article of the reason and use for the three LEDs. Can you explain them? I would like to couple the SD Card Recorder/Player to the 12V 20W Stereo Amplifier module in the May 2010 issue, for use in a caravan with a normal 12V DC supply. Are the output of the SD card machine and input of the stereo amplifier compatible? Can the SD card volume control be modified to provide a balance control and use only the stereo unit's volume control?

While I realise the SD card machine can drive headphones directly, no distortion figures were published so in my quest for higher fidelity sound, I am wondering if either of the headphone amplifiers from the April & September 2011 issues would be compatible with the SD card unit?

I would really appreciate some help and advice in these areas. (J. C., via email).

- LED3 (yellow) is the infrared command acknowledge LED and flashes in response to the reception of infrared commands. LED2 (green) lights when playing a file and also during initialisation. LED1 (red) lights during recording. LEDs1 & 2 flash if there is no memory card inserted.

You can connect the output of the SD Card Music/Speech Recorder/Player to the 12V 20W Stereo Amplifier from May 2010. You just need an appropriate cable (eg, 3.5mm stereo jack to 2 x RCA plugs).

You could turn VR2 into a balance control by cutting the tracks connecting to the left and right front pins on the pot (ie, those closest to the edge of the PCB) and swapping them over using short lengths of wire. This wouldn't make a particularly great balance control as its action would be mostly be around the 12 o'clock position and it may not be very linear in operation but it should work.

The THD+N figure provided for the SD Card Recorder/Player is 0.7% at 1kHz. This is quite poor and is mainly due to the noisiness of the DAC outputs in the dsPIC33 chip and the fact that the design does not use the differential outputs of that DAC to cancel some of the distortion.

While an LM833 isn't designed to drive headphones directly, it will do so reasonably well and the distortion figure is unlikely to change when driving headphones because it's already so high.

Stereo Compressor For Panasonic TV Set

I purchased a Jaycar kit for the Stereo Compressor in the January 2012 issue. I use it between the rear panel audio output of our Panasonic TV and the input of an FM transmitter I built. I then listen to the TV on Sony radio headphones.

What I found was the analog tuner audio output (used for Foxtel) was significantly higher than the digital tuner output (used for the FTA channels). The Stereo Compressor has virtually fixed this problem. Incidentally, I contacted Panasonic about this problem, thinking there would be a preset audio gain control, but they couldn't help.

I noticed on some channels with the compressor, particularly Foxtel, that there was an annoying click with some speakers' voices. It seems as though the attack time is too slow, allowing the output to momentarily square up. I reduced the value of RB on both channels from 1MΩ to 330kΩ and the problem is virtually fixed. However it probably could be reduced even further. I have the Level control set fully clockwise. Any comments? (G. B., via email).

- Resistor RB does not affect the attack time. It affects the linearity of input versus output level for the compressor. Without RB, the compressor boosts signals at low levels but by adding RB (1MΩ), the boost is less at low levels as the input level drops. This was done to reduce noise at low signal levels. By changing RB to 330kΩ, you have raised the input threshold level from where signal boost occurs. That reduces the overall range over which the compressor operates.

It may be better to return RB to 1MΩ and reduce the signal level applied to the input by turning back the level control from its maximum position. That way the compressor will not clip for some high level signals.

Having said that, many modern flat-panel TV sets do have automatic gain controls and that applies to models made by Panasonic. It is worth going through the various menus to see if your set has that feature although we concede that many modern sets actually do not have analog audio outputs and you would have use a DAC to decode the TOSLINK digital audio output.

Studio 350 double-mono system query

I have built two Studio 350 High Power Amplifiers from individual parts, using 2SA970 transistors for Q2 & Q3. There are two separate transformer power supplies, one for each module, and I would like to know if there would be any advantage or disadvantage to the performance of the amplifiers in this mono set up if the 10Ω resistors were removed and replaced with wire links in each module.

In the May 2011 edition on page 99 (Ask Silicon Chip), a question on substitute transistors for the Studio 350 mentioned substituting 2SA970s if 2SA1084s were not available or failing that you could use BC556s although their noise figure is not quite as low. Could this work successfully the other way using the lower noise 2SA970 at Q1 for better performance and lower distortion in place of the BC556s or is it impracticable on this board? (P. C., Whitebridge, NSW).

- The 10Ω resistor was used to provide better separation between channels when the modules are used in a stereo set-up with a common power supply. In your double-mono set-up, you can eliminate the 10Ω resistors without any problems. Just short them out. You can also substitute the transistors in the input stages – they should all work, although the change in performance may be small.

Clarification on sacrificial anodes

About a year ago, we moved into our new home and recently had to replace our mains pressure storage hot-water tank due to leakage, as mentioned in your November 2012 article on sacrificial anodes. It was most interesting but I have two questions relating to comments made.

Having some understanding of sac-

How To Dub LP Records To CD

I have a large collection of LP records and 45s. In years gone by, I have spent countless hours recording selected tracks to cassette tape for listening at home or in my car. However, with the demise of cassette tapes, this is no longer viable. What I would like to do is replace my cassette deck with some sort of gadget that would do exactly the same thing, only record them to a USB flash drive or SD card.

Basically, I want to cue a track, press the record button and then the stop button at the end of the track. I would then transfer them to Windows Media Player for burning to CD. I know there are dedicated computer interfaces, software programs and USB turntables available but I have a high-quality turntable and my desktop is nowhere near my sound system.

Do you know of anything along these lines? (R. B., via email).

● Presumably, apart from the turntable, you also have an amplifier with a phono input. The output from the phono preamplifier is the signal that needs to be recorded either via the preamplifier output or at the amplifier output after attenuation to a suitable line level for a digital recorder.

Digital recorders are available from manufacturers such as Denon (eg, DN F650R) and these are available from speciality music stores but rather expensive. Also, there is the Gemini IKEY digital recorder **http://www.ebay.com.au/sch/sis.html?_nkw=Mint+Gemini+Ikey+digital+recorder** and one from Jaycar: **http://www.jaycar.com.au/productView.asp?ID=XC0386**

We recommend recording using the wav file format, sampled at the best rate available from the recorder.

rificial anodes, I am aware that to do that job there must be a good electrical bonding between the metal you are trying to save and the sacrificial anode. In other words, the electrical resistance between the two must be as low as possible.

The sacrificial anode in the example on page 15 bottom picture should still work because the sacrificial anode is connected to the steel rod which is connected to the threaded top which screws into the tank. Provided that the electrical resistance between them is low, it should do the job.

The other question is regarding the Teflon tape. This would help seal the joint but does this not affect the resistance connection between the threaded sections? Would this not prevent the anode from doing its job properly? Is this not a concern and is it common practice to do this?

With the importance of making a sound connection between the two parts, this sounds confusing. (N. T., via email).

● With regard to the badly worn sacrificial anode shown on page 15, it would still be chemically active but the degree of protection would be minimal and the steel nut of the anode would be under severe attack, meaning that the tank will soon start to leak.

With respect to the Teflon tape, it seals the joint against water leakage but the very act of tightening the joint damages the tape so it is no longer contiguous and then there is good electrical connection between the anode and the tank.

In any case, that aspect is easily checked with a DMM switched to its ohms range, after the installation is complete.

Caravan battery protection/management

I recently bought a second-hand camper trailer which has its own 12V auxiliary battery, the same size as a car battery. The battery can be charged either from 230VAC through a multi-stage 5A battery charger or from the towing vehicle. This also allows the vehicle to power the small 90-litre fridge and charge the battery while you are driving.

Prior to our first trip, the camper had been on 230VAC charge for weeks. The battery was charged up to 14V but after only six hours of running the fridge on 12V, the battery voltage had dropped to 10V. This was a little alarming. I thought we'd be able to go for at least a day on a fully charged battery. Should the voltage have been allowed to get that low? It might be the original battery and may be 10 years old. But how would I test it to know if it is any good?

The people selling batteries just said that I needed a new battery and offered to sell me one. But before investing a few hundred dollars in a new battery, I decided to investigate the battery management circuitry. All I found was the battery charger, with no other protection other than a few fuses. I think the Electrolux fridge may have low voltage protection (10V) but I'm not sure. Although this seems to be a typical caravan installation, I think it can be improved.

If I have the chance to charge the battery from a 230VAC supply, the installed 5A charger will take all day to get the charge level back up. What about just getting a bigger charger? If I have to charge from a generator I want to do it as quickly as possible but without damaging it. Are there rules that should be followed, such as the amps of the charger versus the amp-hour rating of the battery?

I investigated the cost of higher current chargers, low voltage disconnect devices and auxiliary 4WD battery isolators. It all added up to a lot of hardware to install and I could easily spend over $500 not including the battery. None of these devices included an ammeter to tell me how much 12V power was being used.

What about using a solar charge controller? These seem to manage battery charging in the same way that a multi-stage battery charger does but with a lot more amps per dollar and more functionality. They monitor and limit the current and prevent the battery from over discharging, which is a key feature I want.

Solar charge controllers are easy enough to get and seem to be going down in price. Many have an LCD panel showing the charge/discharge status, voltage and output current which will help in managing power consumption. Some permit adjustment of individual voltage set points. Some have compact remote displays

Chrysler CD Player Has Comms Link

I have a Chrysler Voyager with a cassette radio and CD changer. The CD changer is defunct and beyond repair so I thought I would add a small MP3 player to save the expense of replacing the entire unit with a new CD player. I propose to just wire the MP3 player into the CD player audio inputs at the radio.

Now it seems there is a 1-wire comms system between the radio and CD changer because if I remove the CD changer, the CD option on the radio stops working. I am guessing that it's an I^2C bus of some kind which works down a single wire (and its shield braid maybe).

My question is this: is there any way to fool the radio into switching the CD audio input on without having to construct some form of decoder for the comms signal? I know that that's difficult to answer without the circuit of the radio but I have been unable to locate a copy and my local Chrysler dealership wants to sell me the $350 manual and will not photocopy the radio pages for me. (D. S., via email).

● There would be communication between the CD changer and main radio/CD/cassette unit. However, it may be a bidirectional communication and so difficult to duplicate. This is especially tricky since the information required would be the CD number in the changer stack, track number and track duration. The sound may stop once the track number duration is ended.

Perhaps the CD changer could be left in place with just the audio signal input coming from the MP3 player rather than from the CD changer. That way the CD function might work.

Another way is to use one of the commercially available FM stereo transmitters that allow the MP3 player to work through the radio.

which are well suited to the inside of a caravan. And all for a lot less than $500.

When 230VAC was available, a relay would isolate the trailer plug and a 12V (13.8V) 20A or 30A industrial switching power supply would supply the controller. How does this sound?

Is it possible to use charge controllers and battery chargers in parallel on the same battery and do they interfere with each other? Additional controllers would provide safe isolation of a range of charging sources from each other, eg vehicle, solar, wind, 230VAC, etc and switching between sources would be automatic.

For example, I'd like a low-cost per amp device to charge quickly from 230VAC at say 20-30A but when this was not available, I'd like to use the MPPT Charge Controller (SILICON CHIP, February 2011) to harvest optimum power from a small solar array (only a few amps when the sun shines) without having to operate switches and plugs.

An article on caravan battery and power management might be an idea. There doesn't seem to be a complete solution out there in automotive accessory world. (M. V., Kellyville, NSW).

● Generally, a battery protector should be used to prevent

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Switchmode Power Supply with ±50V Outputs

Is there a switchmode power supply with outputs of +50V-0-50V or thereabouts? All I can find are supplies with positive DC outputs. I have a Behringer audio mixer that uses an SMPS and delivers +15V-0-15V. Are higher voltages and current outputs available? (K. M., Porirua, NZ).

● While it's quite possible to design a mains switchmode supply with positive and negative output voltages, in practice they're pretty uncommon, at least at that sort of voltage. There are certainly many amplifiers manufactured with switchmode supplies these days and presumably they get custom supplies made (or design them in-house).

The easiest way to do it would probably be to buy two 48V supplies with floating outputs (quite common) and stack them, ie, connect the positive output of one to the negative output of the other. That then becomes your ground rail and the other two outputs are +48V and -48V. That also gets you twice the total power delivery and it's going to be easier to find 48V supplies than ±50V supplies.

The alternative is to use a ~100V supply and generate a virtual ground rail at the half supply point but then you would either need to drive the speaker(s) in bridge mode (ie, two amplifiers per speaker) or you would need large AC-coupling capacitors (electrolytic, several thousand microfarads) from the negative speaker output terminals to the ground rail, rated for at least 63V.

the battery from being discharged below 11.5V. We published the Battery Guardian in May 2002 and the Micropower Battery Protector in July 2004 and in May 2002. While you should have a similar facility in your situation, probably your battery's condition is poor and it cannot maintain sufficient capacity after charging.

A battery can be considered faulty if it does not deliver its capacity after full charging or if it appears to rise to full charge voltage quickly during charging after a discharge. The fast rise in voltage usually means a high impedance cell. It is doubtful that a battery left to discharge over a long period of time without periodic charge or continuous float charging will give satisfactory service after charging.

Typically, a battery should not be charged at a rate greater than 25% of its ampere-hour capacity. For example, a 100Ah battery can be charged at up to 25A. Also typically, a caravan battery charged from the vehicle's alternator will never charge up to its full charge state due to the voltage drops between the alternator and the battery via the leads and caravan connector plug and socket.

The charge is also dependent on the battery isolator between the main vehicle battery and the caravan battery. A Schottky diode isolator could give a difference of 0.3V or more between the main and caravan battery voltages.

A solar charger could be used to maintain charge while there is no mains power or charging via the vehicle alternator. And this can help to provide full charge to the battery where the vehicle alternator cannot.

On your question as to whether it is possible to use charge controllers and battery chargers in parallel on the same battery and whether they interfere with each other, it depends on the individual chargers as to whether they can be paralleled. If the chargers share a common ground they should be able to be paralleled. Also if a charger is fully floating (eg, solar charger) then paralleling should also be possible.

During charging, parallel chargers will provide for increased charge current during bulk charging. Once charged or close to full charge, the charger with the lowest cut-off voltage will cease charging first, followed by the second charger as the voltage reaches its cut-off voltage. Absorption charge (if available) will be dominated by the charger with the highest cut-off voltage.

Similarly, during float charge, this will be dominated by the charger with the highest float voltage.

It is worth referring to the article by Collyn Rivers on solar power for caravans in the July 2003 issue of SILICON CHIP and also his books on the subject at **http://www.caravanandmotorhomebooks.com/books/**

Gas stove igniter circuit wanted

I am a long time reader and builder of your projects; This time, I am interested in adapting the High Energy Electronic Ignition from the November & December 2012 issues to light the gas

continued on page 96

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

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Ask Silicon Chip

. . . continued from p94

burners of a stove that no longer has a functioning igniter. I am using a hand igniter but it would be so much more elegant to just press a button!

On another topic, I built myself a 3-bedroom house in the late 1990s, with 230VAC power points and all lights wired for 12V DC. Solar panels and wind generators charge a 12V battery bank for the lights and a 24V battery bank for a 2500W inverter.

Over the years, I have replaced all halogen and fluoro lights with LEDs, mostly strip lights. This works well for one person and occasional visitors but in winter needs supplementing with a generator. (J. V., via email).

● Have a look at the Jacob's Ladder project in the February 2013 issue. It would do the job but it is probably considerable over-kill and would require a beefy 12V power supply. It would be more efficient if you could adapt the piezoelectric igniter commonly used on outdoor barbecues.

Different module for GPS Frequency Reference

Is it possible to use the EM-406 GPS module rather than the specified Garmin device for the GPS Frequency Reference (Silicon Chip, March to May 2007)? If so, will the PIC need to be reprogrammed? (M. O., Warrandyte South, Vic).

● It should be possible to use the EM406 GPS receiver module in place of the Garmin GPS 15L receiver originally used in the GPS Frequency Reference, without any modifications to either the PIC program or the other hardware. However, you will need to make sure that the EM406 receiver module is placed in a location where it can get a good "view" of the sky, since it incorporates its own patch antenna rather than using an external active antenna as used by the Garmin module.

You might need to have the module external to the GPS Frequency Reference box, like the one described in our recent GPS Timebase projects in February 2013 and in this issue.

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Dog Blaster not effective on wallabies

The recent hot dry weather in our region has forced the local wildlife to venture into suburban areas looking for food. It seems my vegetable garden has proved irresistible for some wallabies.

In an attempt to scare them off, I have set up a solar-powered security light but that has no effect. I am wondering if the Barking Dog Blaster kit (Silicon Chip, September 2012) would keep the veggie thieves at bay. I was thinking of using the security light PIR sensor to trigger the device. If the Dog Blaster is not suitable are there any other detergents (sic) I could use? (B. A., via email).

● Detergents might work if you sprayed the wallabies but is not something we would suggest. Just kidding.

An Ultrasonic Barking Dog Blaster operated by a security light detector is unlikely to deter wallabies. That only leaves more conventional approaches such as having wire meshing or even an electric fence around the garden. If you have a dog that also might work although some dogs are quite tolerant of wild life. SC

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